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INTERFERENCE IN COMMUNICATIONS AND NAVIGATION AVIONICS FROM COM--ETC(U)
JUN 78 E M SAWTELLE, J G DONG

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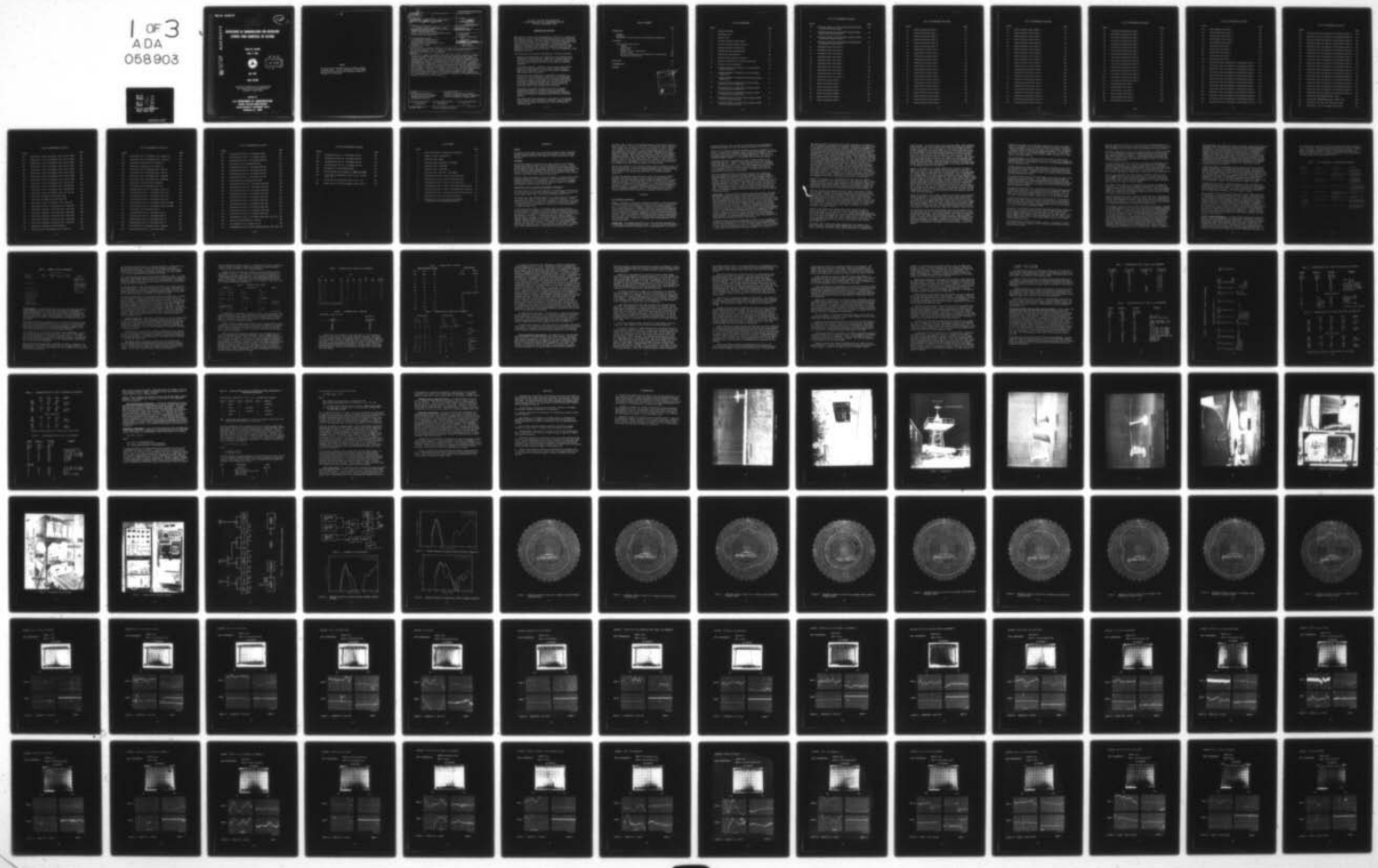

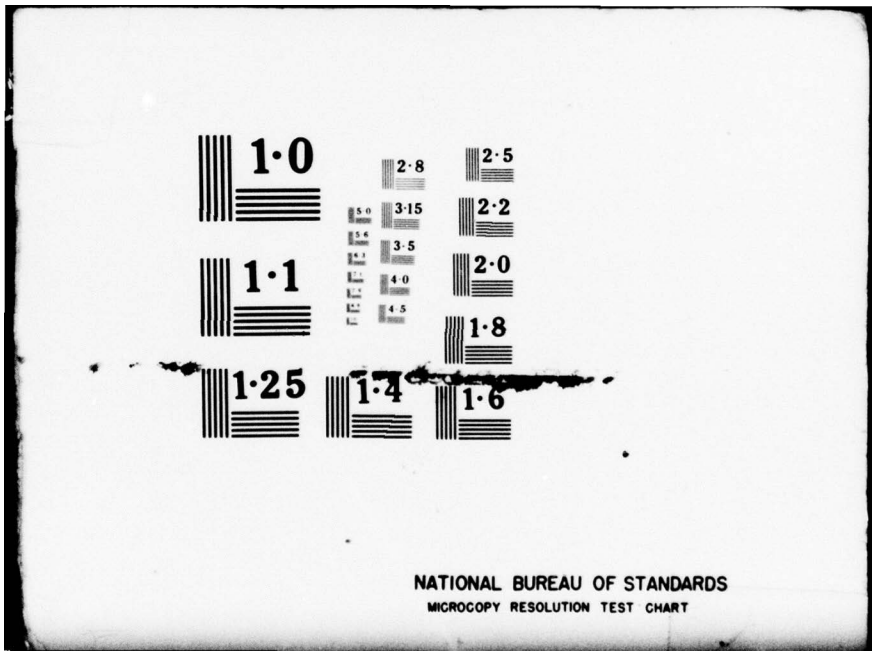
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INTERFERENCE IN COMMUNICATIONS AND NAVIGATION AVIONICS FROM COMMERCIAL FM STATIONS

Edward M. Sawtelle

James G. Dong

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FINAL REPORT

Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
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16. Abstract

The effects of commercial frequency modulation (FM) broadcast stations on communications and navigation avionics were investigated employing several classes of avionics receivers. Flight tests were completed employing site frequencies with intermodulation interference determined by a computer program culling for possible intermodulation products in selected midwestern and southern states. Laboratory measurements were accomplished on the receivers and antenna pattern measurements of typical aircraft antennas were obtained to determine the areas that improvements can best be applied to alleviate the FM interference problem. Results indicate that a 10 dB increase in rejection of FM signals in avionic receivers would eliminate most FM interferences. Included is a proposed method utilizing the Venn diagram approach for predicting possible FM interference assignments under consideration. It is recommended that a flight test program be established to determine FM spectrum signatures and power levels at airports.

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FEDERAL AVIATION ADMINISTRATION
SYSTEMS RESEARCH AND DEVELOPMENT SERVICE
SPECTRUM MANAGEMENT STAFF

STATEMENT OF MISSION

The mission of the Spectrum Management Staff is to assist the Department of State, National Telecommunications and Information Administration, and the Federal Communications Commission in assuring the FAA's and the nation's aviation interests with sufficient protected electromagnetic telecommunications resources throughout the world and to provide for the safe conduct of aeronautical flight by fostering effective and efficient use of a natural resource - the electromagnetic radio frequency spectrum.

This objective is achieved through the following services:

- Planning and defending the acquisition and retention of sufficient radio frequency spectrum to support the aeronautical interests of the nation, at home and abroad, and spectrum standardization for the world's aviation community.

- Providing research, analysis, engineering, and evaluation in the development of spectrum related policy, planning, standards, criteria, measurement equipment, and measurement techniques.

- Conducting electromagnetic compatibility analyses to determine intra/intersystem viability and design parameters, to assure certification of adequate spectrum to support system operational use and projected growth patterns, to defend aeronautical services spectrum from encroachment by others, and to provide for the efficient use of the aeronautical spectrum.

- Developing automated frequency selection computer programs/routines to provide frequency planning, frequency assignment, and spectrum analysis capabilities in the spectrum supporting the National Airspace System.

- Providing spectrum management consultation, assistance, and guidance to all aviation interests, users, and providers of equipment and services, both national and international.

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INTRODUCTION

PURPOSE.

The purpose of this project was to determine distance/frequency separation criteria required between communication and navigation avionics and high-powered frequency modulated (FM) commercial stations operating in common geography.

BACKGROUND.

An increasing number of applications are being submitted to the Federal Communication Commission (FCC) for FM broadcast power increases. Federal Aviation Administration (FAA) frequency management has been opposing these when proximity to runway approaches or other low-altitude routing would expose aircraft with very high frequency (VHF) navigation communication NAV/COM avionics to extraneous power levels capable of causing third order intermodulation or other "brute force" spurious interference.

Distance criteria is necessary to limit FM signals to tolerable signal levels. Frequency planning details are required to avoid intermodulation or other spurious interference. The information is for use by frequency management engineers and is suitable to provide FAA technical support for enclosure with comments to FCC on license applications.

DESCRIPTION OF TEST FACILITIES AND EQUIPMENT CONFIGURATION.

The three primary test facilities employed in accomplishing this effort were the National Aviation Facilities Experimental Center's (NAFEC): antenna test range, Convair 580 aircraft, (N-49), and a laboratory screen room.

The antenna test range at NAFEC (figure 1) is situated where the transmitter site and receiver site are separated by a fresh water reservoir. At the transmitter site (figure 2), the source antenna is a log periodic type, Scientific Atlanta series 26. Equipment for illuminating the antenna is installed in a mobile trailer and the alternate current (a.c.) power is supplied by a standby-type power plant.

At the receiver site (figure 3) the antenna under test was mounted on a curved metal sheet to simulate an aircraft fuselage providing a ground plane for the antenna. A Scientific Atlanta model 1640 CW receiving system with a sensitivity of -95 decibels per milliwatt (dBm) and a model 1530 polar plotter were employed at the site. Antennas tested on the range are shown in figures 4 and 5. In figure 4, the Collins antennas are representative of antennas commonly employed on air carriers. The type 37J-3 is a navigation (VOR and localizer) antenna and the type 37-R2/2U is a VHF communication antenna. The type 137X-1 antenna is a combined unit applicable for communication and/or navigation use. The antenna types A-13B and VRP-15 (figure 5) are of lower quality and used by small general aviation type aircraft.

The Convair 580 aircraft and the antennas employed in the receiver tests are shown in figure 6. Omitted in this figure is an emergency locator transmitter (ELT) antenna which is located 2 feet (0.61 meter (m)) in front of the rear 137X-1 antenna atop the aircraft. Monitoring equipment and test receivers were connected to the aircraft antennas through radiofrequency (rf) power splitters as shown in figure 7 and 8 respectively. The monitoring equipment (figure 7) included a COM 11A receiver, spectrum analyzer, and a 8-channel strip chart recorder. The strip recorder was used to record course deviation indicator (CDI) and automatic gain control (AGC) outputs of test receivers shown in figure 8. Full scale deflection left and right of center for the CDI was adjusted to 25 microamperes (μA) on the recorder. The AGC recordings for each receiver were scaled from zero signal AGC to maximum AGC.

The CDI was recorded for the following receivers: Bendix FA-4165-3A, Escort 110, Mark 12, and NAV 400. On the four remaining channels, the AGC was recorded on the following receivers: COM 11A, KY195B, Bendix FA-4165-3A, and Mark 12. The audio outputs of all receivers was recorded by the 14-channel recorder (figure 8).

The time code generator supplied the real time to the 14-channel recorder enabling time correlation with the flight inspection consoles shown in figure 9. The Dorne and Margolin DM-N-4 antenna was employed with the flight inspection consoles. Details depicting the use of other aircraft antennas with the test receivers are shown in figure 10. A laboratory screen room was employed to simulate with test equipment the effects of strong FM signals on avionic receivers to corroborate recorded characteristics of a live environment of FM commercial broadcast stations. Interference effects of ELT on receivers were also measured using the configuration shown in figure 11.

DISCUSSION

TEST PROCEDURE AND RESULTS.

GENERAL. Preliminary testing was accomplished at NAFEC to obtain charteristics of the VHF NAV/COM systems employed in aircraft and to select suitable equipments to be tested in an environment of commercial FM broadcast stations. Other considerations given in equipment selection for test included equipment population and availability. The test results were expected to determine the cause of present FM interference problems and develop techniques for setting certain constraints in frequency assignments to prevent future FM interference problems. Basic investigation of FM interference was directed towards antenna tests, NAV/COM receivers tests in a live FM commercial broadcast environment, and laboratory tests. Included is a suggested Venn diagram approach for predicting interference.

ANTENNA TEST. The antennas selected for test were considered representative of those used in general/commercial aircraft. Frequency response characterstics of the antennas were made to estimate the rf levels expected at the receiver.

Antenna patterns were also recorded in the horizontal plane simulating the variations in signal level with the horizontal position of the aircraft.

Results of the frequency response measurements are shown in figures 12, 13, and 14. Patterns of some antennas tested at different frequencies are recorded in figures 15 through 23 exhibiting antenna response with respect to the receiving antenna orientation to the transmitting antenna. The gain of the reference standard antenna is 2.15 dB greater than an isotropic antenna.

Measurements were also accomplished on similar antennas mounted on the Convair 580 aircraft. A Hewlett Packard spectrum analyzer with ancillary modules was used as a receiver. A signal generator was used to illuminate the dipole antenna used as a source. The source antenna was placed 15 feet (4.5 m) from the aircraft and within the line of sight, between the two 137X-1 antennas at the rear of the aircraft. The dipole was positioned horizontally and vertically in this plane.

With the horizontally polarized navigation antennas and the vertically polarized communication antennas receiving orthogonal (cross-polarized) polarized signal, the reduction of the signal of the orothogonal polarized signal at the receiver was reduced 20 dB in the frequency range of 88 to 118 MHz. The Dorne and Margolin DM N-4 antenna was not employed with the test receivers because the received FM signal level was at least 5 dB less than other VHF antennas on the aircraft. The increased loss was attributed to the longer cables lengths required to reach the vertical stabilizer on the aircraft. In addition, the DM N-4 antenna was designed to have substantially greater discrimination against vertically polarized signals than the ramshorn- or VEE-type antennas.

FLIGHT TESTS. Using the airborne equipment described previously, instrument approaches and tracks were flown at the following locations: Atlantic City, New Jersey; Indianapolis, Indiana; Kansas City and Topeka, Kansas; Denver, Colorado; Albuquerque, New Mexico; San Antonio, Houston, Dallas, and Ft. Worth, Texas; Birmingham, Alabama; and Opa Locka, Florida. Prior to any flight tests, combinations of the FM frequencies being radiated by FM stations near the selected airports were culled by a computer to determine the test receiver frequencies to be used in flight. In addition, the NAV/COM receivers were tuned to the respective site frequencies authorized at the sites and suspected of having intermodulation interference resulting from commercial FM broadcoast station. Also, the high power FM station towers were designated on the air map to assure that the tracks flown would pass above the antennas at minimal altitudes to receive the maximum FM signal the aircraft receivers would encounter. The spectrum analyzer was used to record the presence of FM signals and the dBm levels received at the aircraft.

Preliminary flight testing was accomplished at Atlantic City to establish the FM power levels expected near the selected airports to be investigated and also to test the operation of the data collection equipment prior to departure to other sites with interference problems. A description of the tracks flown at each location is included with the recorded sample of the results. In

each sample (frame), 30 seconds of AGC and CDI recordings for the Bendix and Mark 12 receivers are grouped with a photograph taken within the sample period of the spectrum analyzer tuned to the FM band. Although the photographs of the FM band are not sharply defined, relative amplitudes and frequency separations of the radiation from FM commercial broadcast stations can be observed. The alphanumerics of the spectrum analyzer photographs are the following in sequence left to right; top--dBm reference level, center frequency, resolution; bottom--display mode, frequency span per division. These spectrum photographs were taken from display of the video tape playback. The video camera was used in lieu of oscilloscope Polaroid® camera. The video tape continuous recording of the spectrum allowed selection of particular samples that could not have been followed by the Polaroid camera because of the rapid changes in the spectrum signal amplitude during flight. The receiver's audio interference was recorded on the 14-channel recorder and time correlated with the other data. Most of the selected sample frames were of the Mark 12 because of the perceptible deviations in the CDI and/or AGC in the strip chart recordings which were indicative of interference. The specific type (i.e., motorboating, hum, music) could not be determined from the chart recordings except as noted for speech or music below. Using time for correlation, the audio recordings were checked for the type of interference observed on the strip charts.

Results of the flight test at Indianapolis-Weir Cook Airport are shown in figures 24 through 33. The track was flown at a mean sea level (MSL) altitude of 2500 feet (762 m) along a route beginning at the Shelbyville, Indiana combined VOR and TACAN system (VORTAC) thence via Victor Airway 97 to the Zippy intersection (32 nautical miles (nmi) northwest of Shelbyville VORTAC), procedure turn, thence return to the Shelbyville VORTAC via Victor Airway 97.

From the selected frames assembled from the flights accomplished in Indiana, only one frame indicated that no interference was present in either navigation receivers. However, in subsequent flights near the same location, interference did occur in the Mark 12 receiver. The number of frames and the types of interference recorded from the Mark 12 receiver were: four frames with motorboating sound, four frames of interference from music, and one frame with heterodyning. In the AGC and CDI sampling of the Mark 12 receiver, with music interference numerous minor variations were evident on the strip chart recording. Also, the prime interference signal was apparent in the FM spectrum at the required level.

Results of the flight test at Kansas City Fairfax Airport are shown in figures 34 through 46. The track was flown at an altitude of 2500 feet (762 m) MSL along a direct route that closely tracked State Highway Route 635. This direct route was initiated at the 16 nmi distance measuring equipment (DME) fix on the Kansas City VORTAC 116° radial, thence direct to the 14 nmi DME fix on the Kansas City VORTAC 190° radial, procedure turn, then direct to the initial DME fix, procedure turn, thence a second flight of the described round-robin route.

The sample frames revealed that audio interferences were present in the Mark 12 receiver: three with aircraft engine noise, six with motorboating sound, three with music and/or speech, and one frame with no interference in

either receiver. On the 300° radial, 13 nmi from the VORTAC, high background noise occurred in the Bendix receiver while motorboating sound was present in the Mark 12 receiver. On the 360° radial, 13 nmi from the VORTAC with the aircraft passing above FM antenna number (No.) 6; motorboating sound was present in the Bendix receiver while music was present in the Mark 12 receiver. On the 300° radial, 13 nmi from the VORTAC with the aircraft passing above antenna No. 6; motorboating sound was present in both receivers. The wide trace of the Mark 12 CDI in figure 37 was attributed to 30 Hertz (Hz) oscillations which occurred when the receiver was tuned to the VHF omnidirectional radio range (VOR) frequency. Minor variations when music interference was present occurred with larger and slower changes in the Mark 12 automatic gain control (AGC) curve and were sometimes present in the frames with other types of interferences detected by the receiver.

Results of the flight test at Topeka, Philip Billard Airport, are shown in figures 47 through 58. The track was flown at an altitude of 2500 feet (762 m) MSL from the Topeka VORTAC to the 10 nmi DME fix on the Topeka VORTAC 237° radial, thence at 3000 feet (914.4 m) MSL direct to the 24 nmi DME fix on the Topeka VORTAC 245° radial, thence at 2000 feet (609.6 m) MSL direct to the 6 nmi DME fix on the Topeka VORTAC 292° radial direct Topeka VORTAC, thence a second flight of the described route. Only one frame indicated that no interference was present in either the Bendix or Mark 12 receivers. Other frames include, eight frames with motorboating and three frames with music/speech. When the FM spectrum analysor reference level setting was at -10 dBm (top raster line is -10 dBm for -10 dBm setting) many of the FM stations radiation was not visible on the analyzer. However, at an analyzer setting of -20 dBm the radiation from the many FM stations was apparent when the video tape was viewed in the laboratory. The level setting is the first number on the left at the top of the photograph.

Results of the flight test at Denver, Jefferson County Airport, are shown in figures 59 through 74. The track was flown from the Denver VORTAC direct to the 12 nmi DME fix on the Denver VORTAC 194° radial, thence direct to the 24 nmi DME fix on the Denver VORTAC 240° radial, thence direct to the 22 nmi DME fix on the Denver VORTAC 272° radial, thence direct to the Denver VORTAC. The altitude parameter for this flight was specified as maintenance of 1000 feet (304.8 m) above ground level. Actual flight altitude, due to terrain considerations, ranged from 6500 feet (1981.2 m) to 8600 feet (2621.3 m) MSL.

In the selection of some AGC and CDI samples there were two blanks in the audio data and three in the FM spectrum because of malfunctions in the audio and video tape recorders. Other frames included: two frames with high background noise, four frames with motorboating, and eight frames with music/speech. It seems that the frames with blank audio data, music/speech interference were present in the Mark 12 receiver by observing the similarity of other AGC curves when music/speech interference was present. It should be noted that no interference was present in the Bendix receiver in any of the frames.

Results of the flight test at Albuquerque International Airport are shown in figures 75 through 86. The track flown consisted of two parts to properly cover the FM antenna locations in the area. Part 1 was flown at an altitude of 6300 feet (1920.3 m) MSL from the Albuquerque VORTAC to the 5 nmi DME fix on the 062° radial of the Albuquerque VORTAC, thence direct to the 20 nmi DME fix on the 045° radial of the Albuquerque VORTAC, procedure turn, thence direct to the initial DME fix.

Part two was flown at an altitude of 11,500 feet (3505.2 m) MSL from the Albuquerque VORTAC to the 20 nmi DME fix on the 45° radial of the Albuquerque VORTAC, right turn to and maintain a 20 nmi arc of the Albuquerque VORTAC until the test termination time.

In some locations, the selected frames depicting interference are not within the prescribed tracks originally specified because of deviations imposed by the existing air traffic. Sometimes, tracks were slightly altered to lessen the burden on the local air traffic control or to provide better interference coverage observed during flight.

The results obtained revealed five blank samples in the frames because of poor positioning of the video camera. In all sample frames taken, the Mark 12 received interference, four frames with distorted voice (speech) and eight frames with motorboating sound. The Bendix receiver motorboating interference occurred only in one frame with the aircraft on the 062° radial and 9 miles from the Albuquerque VORTAC.

The results of the flight test at San Antonio International Airport are shown in figures 87 through 102. The track was flown at an altitude of 1800 feet (548.6 m) MSL from the San Antonio VORTAC to the 20 nmi DME fix on the 121° radial of the San Antonio VORTAC, thence direct to 12.5 nmi DME fix on the 177° radial of San Antonio VORTAC, thence direct to the San Antonio VORTAC.

No audio interferences were received by the Bendix receiver. Interferences received by the Mark 12 receiver consisted of nine frames with motorboating sound and seven frames with music. Music interference was received within a mile of the outer marker on approaches and flying a track on the 158° radial at 13 and 16 nmi from the San Antonio VORTAC.

The results of the flight test at Houston, Hobby Field are shown in figures 103 through 113. The track was flown at an altitude of 1200 feet (365.8 m) MSL from the Houston VORTAC to the 19 nmi DME fix on the 182° radial of the Houston VORTAC, thence direct to the 12 nmi DME fix on the 177° radial of the Houston VORTAC, thence direct to the 12 nmi DME fix on the 170° radial of the Houston VORTAC, thence direct to the Houston VORTAC, thence a second flight along the described route.

No interference was received by the Bendix receiver. Interference received by the Mark 12 receiver consisted of eight frames with motorboating sound and three frames with music.

Music was received by the Mark 12 receiver at the following locations: on an approach runway 13, 1 nmi outside of the outer marker, on the 184° radial 16 nmi from the VORTAC, and on the 170° radial 12 nmi being over FM antenna number 3.

Approaches accomplished at Dallas, Love Field, are shown in figures 114 through 118. No interference was received by the Bendix receiver, but motorboating was present in the Mark 12 receiver. In some frames the AGC trace with many small rapid variations are similar to traces observed when music/speech was present. It seems to imply that music/speech might be present but was masked by the motorboating sound.

The track completed in Dallas, Love Field , and Regional Ft Worth/Dallas was comprised of three parts. Part one was flown at an altitude of 1800 feet (548.6 m) MSL from the Greater Southwest VORTAC (GSW) to the 15 nmi DME fix on the 151° radial of GSW VORTAC, thence direct to visual check point Gears, cross Gears at 2500 feet (762 m), thence direct to the 12 nmi DME fix on the 217° radial of GSW VORTAC, procedure turn, thence direct to the initial DME fix.

Part two was accomplished at a MSL altitude of 4000 feet (1219.2 m) from Scurry VORTAC direct to visual check point Gears via the 203° radial of the Scurry VORTAC. Part three required the aircraft to be flown at an altitude of 4000 feet (1219.2 m) MSL from the Love VORTAC direct to visual check point Netty via the 232° radial of the Love VORTAC.

The results of the flight test in Dallas/Ft Worth are shown in figures 119 through 150. No interference was present in the Bendix receiver during the flight test while it was evident in the Mark 12 receiver. From the 32 samples assembled, 15 frames had interference from music, 12 frames with motorboating sound, and 5 frames with high background noise which also includes the frames with noise and motorboating combined.

Several months later by request, additional flight tests were accomplished in Alabama, Birmingham Municipal Airport, and Florida, Opa Locka, using basically the same test equipments. To obtain a better reproduction of the FM spectrum, a motion picture camera was used in conjunction with the video camera viewing the oscillosope presentation on a special split image mirror.

At Birmingham, instrument landing system (ILS) approaches were made. Included in the flights were orbits of 5 nmi and a track from the Birmingham VOR direct on the 150° radial to a distance of 15 nmi and returning to the Birmingham VOR via the 150° radial. No rf interference was detected by the Bendix and COM 11A receivers during the flight. Hum and motorboating sounds were apparent in the King 195B, Mark 12, Escort 110, NAV 400, and Genave 100 receivers. In addition, during one of the approaches and one of the 5 nmi orbits, intervals of music/speech-type of interference were detected by these receivers. While on one of the ILS approaches, the ILS transmitter was reduced 12 dB from the normal 180 watts output to determine its effect on interference. Subsequent approaches with full transmitter power indicated no effect from reduction of ILS transmitter power on FM interference. Figure 151 shows the variations in FM spectrum for a brief period time during an ILS approach

when music/speech interference was present, and figure 152 shows the FM spectrum changes for short time during the 5 nmi orbit when music/speech interference was present. It was observed during this flight test that the FM spectrum changed slower than spectrum changes at other locations. Consequently, it is suspected that the rate of change in the FM spectrum during a flight is related to the number and location FM stations relative to the aircraft and peculiarities in the ground environment. To improve the correlation of the FM spectrum with rf interference, a digital data collection system is being considered for purchase which will allow better reproduction of the spectrum from the digital tape recording and permit signal processing to be executed on the spectrum with the associated computer and compared with receiver parameters and aircraft position.

At Opa Locka Airport, ILS approaches made on runways 9L and back course 27R caused no interference in the Bendix and COM 11A receivers. Hum and motorboating sounds occurred in the King 195B, Mark 12, and NAV 400 receivers during the four ILS approaches on runway 9L, two VOR approaches on runway 9L, and four ILS approaches on runway 27R. Intermittent receiver noise bursts occurred on the Escort 110 during one ILS approach on runway 27R. The ILS approach frequency was 110.5 MHz. Music/speech interference was detected by the Genave 100 receiver tuned to 120.7 MHz during an ILS approach on runway 9L and two ILS approaches on runway 27R with the receiver tuned to 121.9 MHz.

A request was made by the air traffic controller to check 120.7 MHz for rf interference on the ground. During the ground check, there was heterodyning (high pitch whistle) in the audio of the COM 11A receiver, but desired speech would override the interference. In the Genave 100 receiver, intermittent burst of music/speech occurred at the end of runway 9 taxiway.

Since the Mark 12 and Bendix receivers were used to give a comparison of the rf interference effects on navigational receivers, table 1 shows the effects of interference on communication receivers. The communication receivers were not as susceptible to FM interference compared to navigational receivers; therefore, only the results obtained at Topeka are depicted as an example of airborne communication receivers behavior in FM interference environment. As listed in the table 1, the Genave 100 receiver was the most susceptible to the interference. This receiver is a low-cost, general-aviation type receiver. The effects of the Sharc 7 ELT had no effect on the amount of interference because the FM signal was not sufficient in magnitude. In the N49 aircraft there was also a Narco ELT 10 which is the regular unit installed in the aircraft, but this ELT antenna located near the tail was too distant from other antennas to have effect.

SUMMARY OF AUDIO INTERFERENCES. A listing of audio interference is found in table 2. The most prevalent types of interference occurring in the Mark 12 receiver were motorboating sound and music/speech. The aircraft noise, which sounds like a single engine aircraft, may be considered a variation of the motorboating sound. The motorboating sound could vary in pitch, level of loudness, and frequency of bursts. Music/speech type of interference may be clearly audible or sometimes distorted. The high background music may be similar to a high level of receiver noise or may include high level hum. The

heterodyning noise may sound like a high pitch whistle and only occurred in one of the frames. These interferences were evident in the Mark 12 receiver which is considered a general-aviation type navigational receiver. In the Bendix high quality receivers, the only location that interference was evident in this receiver was at Kansas City, Fairfax Airport, where three of the sample frames showed high background noise.

TABLE 1. AUDIO INTERFERENCE IN COMMUNICATION RECEIVERS

Flight Action	COM 11A	King 195B	Genave 100
1. ILS Runway 13	121.7 MHz No Interference	121.7 MHz No Interference	118.7 MHz Continuous Motorboating Sound
2. ILS Runway 13	121.9 MHz No Interference	121.9 MHz Starting at 7 nmi Heterodyning and Motorboating 37 sec duration	118.7 MHz Starting at 8 nmi Noise 8 sec duration; at 4 nmi Music 6 sec duration
3. ILS Runway 13	118.7 MHz Starting at 5.5 nmi Garbled Speech 4 sec duration	118.7 MHz No Interference	121.7 MHz Starting at 7 nmi Garbled Speech 3 sec duration and at 5.5 nmi Music 1 1/2 min duration
4. ILS Runway 13	118.7 MHz No Interference	118.7 MHz No Interference	121.7 MHz Starting at 7 nmi Garbled Speech 3 sec duration at 5.5 nmi Heterodyning 3 (8 sec bursts)
5. BC Runway 31	121.9 MHz No Interference	121.9 MHz Starting at 7 and 5.5 nmi Garbled Speech 1 and 5 sec duration	118.7 MHz continuous Motorboating sound
6. BC Runway 31	121.9 MHz No Interference	121.9 MHz Starting at 7 nmi Heterodyning	118.7 MHz continuous Motorboating sound
7. Topeka VOR 237°R/10 P→ 245°R/24 D→ 292°R/6	121.9 MHz No Interference	121.9 MHz No Interference	118.7 MHz Starting at 7 nmi Music 25 sec duration 20 to 23 nmi Music 3 (5 sec bursts
8. Reverse of Flight Action 7	121.9 MHz No Interference	121.9 MHz No Interference	118.7 MHz Starting at 9 nmi Music 25 sec duration outbound near KTOP

TABLE 2. SUMMARY OF AUDIO INTERFERENCES

Flight Test Location	Number of Occurrences: Aircraft Noise	Motorboating Sound	Music/Speech	Background Noise	Remarks
Indianapolis-Weir Cook		4	4		One occurrence of Heterodyning and one frame with no interference
Kansas City-Fairfax	3	6	3		3 frames with high background noise in Bendix receiver. One frame with no interference
Topeka-Philip Billard		8	2		One frame with no interference
Denver-Jefferson County		2	9	3	2 Blank recordings
Albuquerque-International		8	4		
San Antonio-International		9	7		
Houston-Hobby Field		8	3		
Dallas-Love Field		5			
Dallas-Love Field and Regional Ft Worth/Dallas		12	15	5	

RECEIVER TESTS. The objectives of these tests were to provide baseline data on the NAV/COM receivers for selectivity and sensitivity performance at several frequencies across the VHF band before adding the interfering intermodulation FM signals. Also, tests were made for the two parameters with one, two, and three FM signals being introduced to selected receivers. With each combination, the effect of an Emergency-Locator-Transmitter (ELT) was determined.

The laboratory tests were conducted in a large screen room using the arrangement shown in the block diagram of figure 11. Not shown is an audio sweep generator used to modulate one of the signal generators. During certain tests on the NAV receivers, the Precision ILS/VOR Signal Generator, Cossor type CRM555 was used in lieu of an HP 8640B signal generator.

The ELT used in all of the tests in this report was a Leigh/SHARC-7. (At no time during the tests was the ELT energized.) The location of the SHARC-7 antenna was changed from 3 1/2 inches (9 centimeter (cm)) to 5 feet (152 cm) from the VHF 137X antenna to test for the AGC level response. Testing showed that in the particular environment of the lab a maximum effect was achieved with 4 feet (122 cm) of separation.

While the Narco-10 ELT was tested to determine its effect on receivers, none was observed at the maximum power levels using the HP signal generators. The maximum level at the ELT was approximately +3 dBm, depending on the frequencies of the FM signal generators.

The test environment was found to be frequency sensitive. During the test it was necessary to monitor the receiver and ELT FM signal inputs with a Tektronix spectrum analyzer. Loss through the splitters was approximately 10 dB, but due to the nonlinear frequency response the loss varied between 5 and 15 dB for frequencies between 88 MHz and 136 MHz.

The results of these tests were plotted using the HP-Mosely 2 DR-2. For these tests the HP 8660B signal generator was set at a center frequency and swept an appropriate amount either side to achieve the plots presented. For sensitivity curves the center frequency selected was usually 98.0 MHz and this was swept ±10 MHz from 88 MHz to 108 MHz.

The receivers tested in the laboratory were all those of the flight test plus the EDO-AIRE PRT-551. Sensitivity using multiple FM signals and selectivity plots of the Bendix receiver were not produced as there appeared to be no interference generated from the FM intermodulation signals; however, during flight testing some interference to the Bendix receiver was observed.

The figures presented may have the signal generator "settings" given, in which case an average 10 dB must be subtracted to reach the actual level at the ELT and receiver. A representative sample has been selected to illustrate the effects of strong FM signals on avionic receivers. The curves shown were made by the AGC driving the Y amplifier of the X-Y plotter and sweep voltage from the signal generator (SG-2) driving the X amplifier. The levels of AGC voltage are not directly relatable to the interference consequently a distortion meter was used to monitor the output of the receiver under test. The meter was set to monitor the distortion at 1 kilohertz (kHz). As the test progressed, the meter reading was at times paired with an aural evaluation of the interference. Aurally, the distortion above 15 percent became objectionable to those recording the data.

Receiver Selectivity. Measurement of selectivity is the "true selectivity" of the receiver where two or more simultaneous signals are applied and the effects on the receiver include desensitization, cross-modulation, and signal breakthrough. Representative selectivity response curves are presented in figures 153 through 186. Loss of selectivity is evidenced by observing the increase in the width of the curve detent (bandpass) or decrease in the depth of the detent (skirt).

The response of the receivers to frequency combinations is not uniform with regard to signal levels nor relative to whether the ELT antenna was connected or not connected. Consequently, analysis of each group of curves will not be attempted; however, a limited number of the figures will be discussed to highlight important points.

The general shape of selectivity response curve for the particular King 195 receiver tested are represented by figures 168 and 169. In figure 169 two intermodulation FM signals were added to the 118.1 MHz AM signal at -50 dBm. The ELT and 137X antennas were separated distances listed in the legend. The two sets of curves had very similar input parameters

with the exception of antenna spacing. The spacing did not have a significant effect on receiver response. Other tests settled on the larger spacing as standard for all tests where it was a fixed parameter.

Figures 174 and 175 reflect the increase in distortion which occurs in the presence of the ELT. In figure 174 the first five curves present the response of the receiver without the ELT. The distortion of these curves is to be compared with the higher numbered curves taken when the ELT was connected. The precent of distortion to the 1 kHz audio modulation on the AM signal at 118.025 MHz is much higher with the ELT connected. The same is true for a similar comparison in figure 175.

TABLE 3. DISTORTION TEST, GENAVE

FM Signal				AM Signal Inputs				Remarks
SG-1		SG-2		SG-3		SG-3		
106.477 MHz		90.0 MHz		122.8 MHz		122.8 MHz		
RCVR	ELT	RCVR	ELT	with ELT		No ELT		
dBm	dBm	dBm	dBm	dBm	Percent Distortion	dBm	Percent Distortion	
-6	0	-6	0	-40	21	-60	13	Unacceptable
-16	-10	-6	0	-60	20	-90	15	Unacceptable
NON-INTERMOD FREQUENCY								
100 MHz		90 MHz		122.8 MHz		122.8 MHz		
+0.4	0	-6.4	0	-70	6	-70	6	No Interference

A comparison of distortion is presented in table 3 with and without intermodulation frequency. The response with the ELT resulted in more severe distortion, but the ELT effect dropped out below the 0 dBm ELT input as seen in table 4. These data reflect the critical level of diode action in the ELT below which the ELT is completely passive.

Tables 3 through 7 percent distortion data from a single AM and FM signal combination of up to three FM signals. When the ELT is connected, the percent distortion may be expected to be higher than without the ELT. A very high level of distortion without the ELT is 36 percent, while with the ELT distortion can rise to 90 percent.

Table 4 reflects the distortion response from two FM signals which produced an intermodulation interference frequency. Again, response with and without the ELT is presented. The next to last line of the table reflects the critical levels that must be at the receiver input to generate interference, i.e., reduction of signal by 3 dB from -13 to -16 dBm dropped the distortion from 44 percent to 0 percent. Finally, in table 6 the three FM frequencies were selected to produce an intermodulation frequency of 121.1 MHz to which the EDO-AIRE receiver was tuned. As seen, even without an ELT, the distortion was present at an objectionable level with signal settings at -20 dBm for all receiver inputs. Again, approximately 10 dB must be subtracted to arrive at the actual receiver input level of -30 dBm.

TABLE 4. DISTORTION TEST, KING 195B, 3 FM SIGNALS

Inputs									
SG-1			SG-2			SG-3			
Freq. MHz	Rec -dBm	ELT -dBm	Freq. MHz	Rec -dBm	ELT -dBm	Freq. MHz	Rec -dBm	ELT -dBm	Distortion Percent
107.9	10	1	121.3	70	-	94.5	2	1	46
107.9	10	1	121.3	140	-	94.5	2	1	46
107.9	10	-	121.3	140	-	94.5	2	-	0
107.9	10	-	121.3	70	-	94.5	2	-	11
107.9	11	2	98.0	3	3	94.5	4	2.5	46
107.9	11	-	98.0	3	-	94.5	4	-	23
107.9+	13	0	98.0	*14	13	94.5	13	1	44
107.9	13	-	98.0	14	-	94.5	13	-	0

*SG-2 for -dBm 10 to 80 same distortion
+ for 107.9 reduced to -16 dBm, Distortion = 0

TABLE 5. DISTORTION TEST 3, EDO-AIRE

SG-2 AM Mod. 1 kHz 118.1 MHZ

(-dBM)	Distortion (Percent)
60	11
70	10
80	10
90	16
100	26
120	26

Tables 3 and 7 are presented to show the effect on the distortion for particular FM interference levels for two different receivers. The levels at which distortion becomes objectionable would not be expected in terminal areas near airports unless the transmitter site is located several miles from the airport. The first table (Genave Alpha 10) shows the condition of intermodulation and nonintermodulation signals with the ELT. Table 5 data were recorded without any FM interference signals. The observation is made that with intermodulation signals, interference will probably occur even at high VHF signal levels.

TABLE 6. DISTORTION TEST 4, EDO-AIRE

Signal Generator Settings			Distortion ELT	
SG-1	SG-2	SG-3	With	Without
dBm	dBm	dBm	Percent	Percent
5	0	15		36
0	-10	0		29
-10	-20	-10		25
-20	-20	-20		25
-20	30	-20		11
10	10	10	90 (no Audio 40-1200)	
0	10	0	84	
0	0	0	47	
-10	-10	-10	29	
-20	-20	-20	24	
-20	-30	-20	10	

TABLE 7. DISTORTION TEST, KING 195B, 2FM SIGNALS

FM Signal Inputs				AM Signal Inputs				Remarks
SG-1		SG-2		SG-3		SG-3		
103.33 MHz		90 MHz		127 MHz		127 MHz		
RCVR	ELT	RCVR	ELT	With ELT		No ELT		With ELT
dBm	dBm	dBm	dBm	dBm	Percent Distortion	dBm	Percent Distortion	
0	0	-0	0	-60	19	-65		Noticed
0	0	-6	0	-65				Unacceptable
0	0	-6	0	-70	37	-70	5	Worse
104.085 MHz		90 MHz		118.025 MHz				
-0.8	0	-6	0	-30	8	-65		Noticed
-0.8	0	-6	0	-35	-	-		Unacceptable
-0.8	0	-6	0	-40	27	-70		Worse
-10	-10	-6	0	-40	9	-70		Noticed
-10	-10	-6	0	-50	26			Unacceptable
-10	-10	-6	0	-60	26			Worse

In figure 177 the level of the AM signal at 122.8 MHz is maintained at -60 dBm through the first 8 curves. The levels of the two FM signals are decreased progressively from curve 1, while selectivity progressively improves. This response to the intermodulation interference is considered to be typical. Figures 178 through 180 contain additional data for two FM signals of an intermodulation combination with an on-frequency AM signal. Figure 181 presents the condition of two FM signals at high power levels, but not an intermodulation combination at the frequency to which the receiver was tuned. Without the ELT connected, a comparison of curves 12 and 16 shows the distortion percentage to be the same. Curve 16 was made without the strong FM signals. Comparison of the curves shows the effect of the FM signals to be that of a higher AGC voltage base line for curve 12. Noticeable on this figure is that the ELT when connected had little or no observed effect on the receiver performance as contrasted with figure 182. The curves 1 and 2, 6 and 7 of the latter figure are examples of ELT effect on the receiver. Between ELT input levels of -8.8 and -14.0, as seen by curves 5 and 4 respectively, there is a sharp reduction of ELT effect. Figure 183 is a plot of receiver response when the interference FM frequencies did not produce an intermodulation frequency at the frequency to which the receiver was tuned. The FM signal levels were maintained at 0.4 dBm throughout the test. The AM signal generator was swept between 117.9 MHz and 118.3 MHz, and the output set for each curve as listed in the table. Curves 2 through 9, plotted with the ELT connected, illustrate the interference from the ELT when compared to curves 10 through 15 made without the ELT connected. Curve 2 made with the ELT connected shows the large shift in AGC voltage from the level of curve 1 which occurred due to the ELT. Review of figures 184 and 185 provides further examples of ELT adverse effect on the selectivity of the receiver and increased distortion present with the ELT connected in the laboratory configuration.

In figure 186 the base lines of the three sets of curves were shifted to prevent overlaying and for clarity. As with previous examples, the interfering FM signals have caused AGC voltage to develop, resulting in a loss of selectivity. When the interfering signal levels reach the high level of the lower set (curves 8-13) selectivity has become a small percentage of the original design selectivity when compared to the top set (curves 1-6).

The distortion increases to very high levels with increasing interference signal levels. The observation should be made that any calculation of potential interference for a general aviation receiver in the presence of strong FM signals should not be based on the specified selectivity of -60 to -70 dBm.

Receiver Sensitivity AGC Response. The sensitivity in a receiver determines the extent it is capable of receiving a desired signal. The desired signal level curve used as a reference contains only the desired AM signal. Deterioration of sensitivity is reflected in the curves displaying a divergence from the reference when FM signals are applied. The figures on sensitivity of receiver AGC response are organized by receiver type. Test results of all receivers were not obtained for single AM and multiple FM interference signals, but an adequate number were conducted to provide a

satisfactory guide to general aviation avionic receivers performance. As with most tests, hindsight would have resulted in different test conditions; however, of the many figures a few will be reviewed in detail to point out aspects considered important.

Figure 187 is representative of curves for receivers tested showing Escort 110 receiver response to single FM signals of 0, -10, and -20 dBm relative to an AM signal which was discretely set between -65 and -85 dBm. In the legend of the figure, AM signals are shown in parenthesis, and as in curve 2 are combined with an FM signal of -20 dBm. Short sections of an X-Y plot are presented for the three AM frequencies tested. For the tests the FM signal generator was swept from 88 to 108 MHz on an 18-inch plot. The response across the entire band/18-inch plot is well represented by these short sections as levels did not vary significantly across the entire plot.

The receiver sensitivity of figure 187 is unaffected by the FM signal once the AM signal is at least -65 dBm even for an FM signal of 0 dBm. At a level of -75 dBm for the AM signal (curve 4), the AGC voltage is increased by an FM signal of at least -20 dBm since the level is the same for -10 dBm and 0 dBm (curve 5). The distance between curves 1 and 6 represents 20 dB; therefore, depending on the AM frequency, the introduction of -10 dBm FM signal (curve 3) results in a 10 dB or more loss of sensitivity.

A test which demonstrates the above occurrence was conducted with the King 195B. The sensitivity at 118.0 MHz was found to be -105 dBm. The AM signal level was increased to -95 dBm and modulated at 75 percent with 1 kHz. An FM signal at 98 MHz was then introduced to the receiver along with the AM signal via a power splitter. When the FM signal was raised to -20 dBm the clear audio of 1 kHz became intermittent. At -10 dBm the AM audio was completely lost and a 10 dBm loss of sensitivity was established. At -75 dBm AM signal level the effect of the FM signal diminishes until at -65 dBm AM signal level there is no apparent effect on AGC level by the single FM signal up to 0 dBm.

The curves of figure 188 were produced in the same manner as those of figure 187. Other figures of this type are shown through figure 227.

For curves 1 through 4 of figure 188 there was no rf input from the FM signal generators labeled SG-1 and SG-2; however, an X-axis sweep voltage produced by SG-2 was used to drive the X-Y plotter while the AGC voltage of the receiver was recorded for an SG-3 input at 108.3 MHz. Several power level settings were successively set for SG-3 thereby producing the four curves (levels) shown. Curves 5 through 9 were produced by setting the SG-1 and SG-2 signal generators to the levels listed. The ELT was connected where an X is listed under the column for "ELT Con". When the FM signals were introduced, the AGC voltage of the receiver changed from the -75 dBm level as shown to a lower level. Signal generator SG-1 was held at 103 MHz, while SG-2 was swept from 88 to 108 MHz. Near the midpoint of the sweep, an intermodulation frequency of 108.3 MHz was generated which caused the AGC voltage of the receiver tuned to 108.3 MHz to dip according to curves 5 through 9.

The settings listed for each of the signal generators are approximately 10 dB higher than the input levels at the receiver and ELT as described earlier. In other figures, actual measured input levels may be listed for the receiver and ELT.

Figures 189 through 193 are additional plots of intermodulation tests conducted with the Escort 110 receiver. The tests were made with two FM interfering signals and an AM signal to which the receiver was tuned. Figure 189 was made using the VOR/ILS simulator in lieu of the standard AM signal generator. In addition to the AGC response shown in curves 1, 2, and 3, the remarks column recorded CDI deflection and flag action as the FM frequency was swept by SG-2 between 88 MHz and 108 MHz. Figures 190 and 191 were plotted for different FM frequency combinations then for figure 189. The consequence was that many more intermodulation responses were recorded in figures 190 and 191. The curves show that FM interference effect declined as the AM signal level increased. In figure 190 the effect was still occuring at -40 dBm AM signal and in figure 191 at -50 dBm some slight effect is still present.

Figure 193 is a representative example of AGC response. For clarity the X-Y plotter Y position setting was adjusted to separate the curves; therefore, the shift does not reflect a change due to FM signal level effect on the AGC voltage. The AM signal level input to the receiver was held constant at -70 dBm.

The data block listing curve parameters was placed so as not to obscure any significant changes in AGC voltage. This is true for all figures of the report. The values listed in the table are those taken while SG-3 was at a value of 98 MHz even though, to produce the curves of the figure, SG-3 was swept from 88 to 108 MHz. Curve 1 was drawn with the ELT antenna connected to the rf signal generators while curve 2 was drawn with the ELT disconnected from the generators and the feed line terminated in a 50 ohm load. The signal generator settings remained the same, but changes to levels of the input to the receiver changed as listed for curve 2. Usually there was no input level change observed when the ELT antenna was disconnected.

Several times as the signal generator SG-3 was swept from 88 to 108 MHz an intermodulation frequency was generated which resulted in AGC voltage response. Those intermodulation frequencies generated with the exception of the pair at the top end of the sweep may be attributed to the ELT. The ELT was disconnected for curve 2 and all AGC responses indicative of intermodulation frequency were eliminated except for the pair at the top of the band. A comparison between curves 5, 7, and 9 indicates the level at which the ELT action on the receiver was reduced to a low level. Near 0 dBm the reradiation of rf from the ELT stopped so that no AGC indication of intermodulation was generated for this receiver.

Figures 195 through 198 present intermodulation test plots on the Mark 12 receiver using two FM interfering signals and an AM signal produced by the VOR/ILS simulator to which the receiver was tuned. The curves were

plotted with and without the ELT being connected in the test system. The adverse effect of the ELT is clearly seen. Receiver AGC response varied between the several figures as a function of what frequency SG-1 was set to input to the system and the receiver tuning. In figure 195 the receiver was tuned to 109.1 MHz while in figures 196 through 198 it was tuned to 110 MHz.

Figure 199 shows the Genave and EDO-AIRE receiver AGC response to a -85 dBm AM signal and the effect of adding a single FM signal to the receiver sensitivity. In both of these receivers, sensitivity is lost only at the -85 dBm level AM signal and -20 dBm FM signal. At -75 dBm of AM signal there is no loss of sensitivity due to a single strong FM signal.

Figure 200 presents the intermodulation test data for the Genave receiver using three FM interference signals while the receiver was tuned to 122.8 MHz. No significant intermodulation was recorded with the ELT disconnected, but with the ELT connected the interference was extensive. A similar result is repeated in figure 201 where only two FM interference signals were introduced. The receiver did ,however, encounter a small amount of interference with the ELT disconnected.

Figure 202 was prepared with the receiver tuned to 135.85 MHz. With two FM signals inputs at high levels, the recorded interference indications were small even with the ELT connected. In figure 203 this condition is repeated. Three FM frequencies are introduced and the receiver was tuned to 135.1 MHz for curves 7 and 8. The general condition observed was that as the receiver tuned frequency approaches the upper end of the band, the degree of intermodulation interference decreases. Little data was taken at the upper end of the VHF band for lack of intermodulation interference.

The AGC response to a single FM interference signal using the NAV 400 receiver is presented in figure 204. This receiver appears to lose no sensitivity due to the single FM signal input.

Figures 205 through 208 were plotted for the NAV 400 receiver using two FM signals and one AM signal to which the receiver was tuned. AGC response for figures 205, 206, and 208 occurred due to intermodulation interference. There appeared to be no significant difference in response with and without the ELT connected. Figure 208 indicates interference from signal generator SG-1 tuned to 107.9 MHz while the receiver was tuned to 108.3 MHz.

The King 195B receiver AGC response to a single FM interference signal is presented in figure 209. A significant shift in ATC voltage due to FM signal occurred only with the -85 dBm signal. A loss of approximately 3 dBm in sensitivity resulted from a 0 dBm level FM signal. No loss was experienced in the presence of the -75 dBm AM signal.

Figures 210 through 222 present intermodulation test results for the King 195B receiver. Figures 210 through 218 were prepared with two FM interference signals. Figures 210 through 216 held the AM signal generator

frequency at 127 MHz while one FM signal generator, SG-2, was swept from 88 MHz to 108 MHz. The third generator, SG-1, was changed to different FM frequencies as listed on each of the figures. For some frequency selections of SG-1 there was little intermodulation interference generated as in figures 210 through 212. In contrast, figures 213 through 216 have high amounts of intermodulation interference plotted; however, most of the interference shown on these figures is due to the ELT.

Figure 216 was prepared by holding the two FM signals constant while the AM signal level was increased. The listed dial settings are 10 dB lower than the actual signal. As the 127.0 MHz AM level is increased, the effect of the FM signals is gradually reduced even with the ELT connected. A very high AM signal level must be reached before the intermodulation interference is overcome as in curve 7. In this case an input of approximately -45 dBm was required. In figure 217, where the AM signal was 118.0 MHz, the intermodulation effect was not overcome even at -25 dBm input.

Figure 218 was recorded without the ELT connected for curve 1 while the other five curves were made with the ELT connected. A significant reduction to the major AGC deflection did not occur until SG-2 was dropped to a setting of -10 dBm. The inputs to the receiver for curve 6 were approximately -10 dBm and -20 dBm respectively for SG-1 and SG-2 remembering the 10 dB difference between "Setting" and "Input."

Figures 219 and 220 present curves made with three FM interference signals into the King 195B receiver. Curve 1 of figure 219 is marked to indicate the center frequency of the sweeping signal generator, SG-2, when the interference AGC response occurred. For curves 7 to 10, the SG-2 center frequency was shifted to 108 MHz to prevent loss of information at 107.9 MHz. The values listed in the data block were recorded by setting SG-2 at the listed frequency. As may be seen from the listed data, only with the conditions of curve 8 was noise encountered with the ELT being connected.

In figure 220, even though no significant AGC excursions were recorded for curve 2, remarks note that audio interference occurred in the King 195B. The noise was a significant increase over normal background noise. Also on figure 220, curves 3 through 9 were made using the Escort 110 receiver. These curves reflect severe distortion in the recording of AGC and remarks reflect significant "Flag" and "To-From" indicator action.

In figures 221 and 222 a different type of intermodulation interference was briefly tested. The receiver in curve 1 of figure 221 was tuned to 118.9 MHz, the AM signal generator was set at 109.1 MHz, and the FM signal generator was swept from 88 MHz to 108 MHz. As seen, two frequencies were recorded as interferences areas on the curve. Two actual field cases of this type of interference were found at NAFEC. Clear music and voice were heard on the approaches to runways 31 and 22 at NAFEC while flying in a single engine aircraft directly above the ILS localizer antenna to runway threshold. The interference ocurred on communication frequency 118.9 MHz. Two local FM stations together with the ILS frequencies produced the intermodulation frequency as follows:

2 (111.9) - 104.9 = 118.9 MHz
2 (109.1) - 99.3 = 118.9 MHz

The interference effect was reproduced by bench tests on the aircraft receiver type. Tests showed that at -45 dBm of FM signal and -5 dBm of localizer signal the interference would result. Figure 222 presents data on the Com 11A for a test similar to that described above.

Figure 223 shows the effect of antenna separation between ELT and the 137X antenna. As each installation of antennas on board an aircraft may be unique and certainly different from the laboratory environment, the coupling between ELT and the VHF avionics antenna cannot be expected to follow that of this figure.

Figures 224 through 227 illustrate the response of the Com 11A receiver to two FM interference signals. While the interference recorded with the ELT connected is severe, significant interference is plotted without the ELT being connected. Again, when the power to the ELT drops sufficiently, interference is reduced to a level as if it had been disconnected.

The Bendix receiver was not subject to intermodulation interference in the form of audio or CDI deflection based on limited laboratory tests. The effect of a single FM signal with a single AM signal is shown in figure 228. An FM signal of -20 dBm is capable of shifting the sensitivity downward by approximately 6 dB.

CDI AND FLAG RESPONSE FROM FM SIGNALS INTO NAV RECEIVER. The CDI displays the indicated course error resulting from the phase difference between the "reference" and "variable" 30 Hz and the amplitude difference in the 90 and 150 Hz modulation. Interference from FM signals will affect the modulation resulting in errors in CDI reading. If strong FM signals desensitize the receiver where reduced amplitude of modulation is received a flag will appear. The results of laboratory tests of the FM signals on the NAV receivers CDI and flag action is generally presented in the tables which follow. These recordings were made visually from observed flag action and the recordings of the 8-channel recorder shown in tables 8 to 14. Deflection gain of the recorder was adjusted so that full-scale deflection left and right of center was 25 μa in either direction. The maximum deflection of the CDI in table 8 was 8 μa. The variation in CDI current was due to the audio modulation of SG-3, the ILS simulator, and SG-2 which swept between 30 and 1200 Hz at a 1 Hz rate. SG-1 was modulated at 400 Hz while the receiver was tuned to 109.1 MHz.

Simultaneous with the monitoring of the other receiver parameters, the audio output was monitored and was significant; status is included under comments (table 9). Table 10 continues the CDI and flag response with the ELT connected. Table 11 contrasts the Mark 12 with the Bendix 4165 receiver which did not experience interference.

TABLE 8. INTERMODULATION TEST 1, MARK 12, CDI DEFLECTION

SG-1 90 MHz (dBm)	SG-2 102 MHz (dBm)	SG-3 109.1 MHz (dBm)	CDI Current (μA)
-80	-80	-60	0
10	10		1 to 8
5	10		2 to 6
0	10		2 to 6
-5	10		1 to 6
-10	10		3 to 6
-20	10		3 to 6
-10	5	-60	3 to 6
0	0	-60	3 to 6
0	-5	-60	
0	-10	-60	0 to 2

TABLE 9. INTERMODULATION TEST 2, MARK 12, CDI DEFLECTION

Signal	Generator	Settings	Comments
SG-1	SG-2	VOR SIM	
90 MHz	102MHz	109.2 MHz	
dBm	dBm	dBm	
OFF	OFF	-87	Flag at -87
10	10	-70	High White Noise Audio
	99.6 MHz		
10	10	-70	"FROM", High Audio, 25 μA
5	10	-70	"FROM", High Audio, 25 μA
0	10	-70	±20 μA
-5	10	-70	+10 μA
0	5	-70	25 μA Left, 10 μA Right
0	0	-70	25 μA Left, 10 μA Right
0	-5	-70	20 μA Left, 10 μA Right
0	-10	-	15 μA Left, 10 μA Right
OFF	OFF	-70	15 μA Left, 7 μA Right
10	10	-30	With ELT, PEEPING Flag, Defl.
10	10	-40	PEEPING Flag
10	10	-50	PEEPING Flag
10	10	-60	Full Flag

TABLE 10. INTERMODULATION TEST 3, MARK 12, CDI DEFLECTION

Signal Generator Outputs (Approximately 10 dB Above Receiver Input)

SG-1 dBm	SG-2 dBm	VOR/SIM -dBm	Comment No.
10	10	30	1
10	10	60	2
10	10	80	3
10	10	100	4
0	10	30	5
-10	10	30	6
-10	10	60	7
-20	10	60	8
-30	10	60	9
-40	10	60	10
-40	0	60	11

Comments:
1-5 CDI (To) Full scale left 25 µA
6,7 CDI (To) Just below full scale 23 µA
8,9 CDI (To) 25 µA
10 CDI (To) 10 µA
11 CDI (To) 7 µA

SG-1 90 MHz dBm	SG-2 99.5 MHz dBm	VOR/SIM 109.1 MHz -dBm	Comments No.
-40	-10	60	12
-20	-20	60	13
0	5	60	14
-10	0	60	15
-10	- 5	60	16
-10	-10	60	17
0	5	75	18
0	0	75	19
0	- 5	75	20
- 5	- 5	75	21
-10	- 5	75	22

Comments:
12, 13 3 µA
14 Loud Audio, 25 µA (full scale)
15 CDI (To) 8 µA
16 CDI (To) 6 µA
17 CDI (To) 3 µA
18 CDI (To) 25 µA
19 CDI (To) 20 µA
20 CDI (To) 17 µA
21 CDI (To) 10 µA
22 CDI (To) 8 µA

SG-1 90 MHz dBm	SG-2 99.5 MHz dBm	VOR/SIM 109.1 MHz -dBm	Comment No.
-10	-10	75	23
-10	-5	60	24
-10	0	60	25
- 5	0	60	26
0	0	60	27
0	5	60	28
0	0.5	60	29
0	0.3	60	30
0	-5	60 No ELT	31
0	-8	60 No ELT	32
0	-9	75 No ELT	33

Comment:
23 2 µA
14-26 5 µA
27 12 µA
28,29 "TO", 25 µA
30 15 µA
31 25 µA No ELT
32 18 µA No ELT
33 10 µA No ELT

TABLE 11. INTERMODULATION TEST 4, MARK 12 AND BENDIX CDI DEFLECTION

Signal	Generator	Settings	Comments
SG-1	SG-2	VOR SIM	
90 MHz	102 MHz	109.2 MHz	
dBm	dBm	dBm	
0	10	-50	"From" ±25 μA
0	5	-50	±25 μA
0	0	-50	18 μA Left, 7 μA Right
0	0	-50	Strong Audio, ±25 μA
0	-5	-60	18 μA Left, 12 μA Right
0	-5	-70	13 μA Left, 13 μA Right
0	-5	-70	No Deflection
	Bendix FA-4165.3A		
0	-10	-30	Flag at - 30 dBm
10	10	-20	High Audio, 0 μA
5	5 ELT	-20	No Audio
10	10 No ELT	-20	No Audio
OFF	OFF No ELT	-20	P.F. AT - 32 dBm
	109.1		
10	10 No ELT	-20	No Intfer., Freq. Intermod.

TABLE 12. INTERMODULATION TEST 5, MARK 12 AND BENDIX CDI DEFLECTION

	SG-1	SG-2	SG-3	Remark
MHz	103.6	98.0	109.2	
dBm*	-7	-10	-65	To/From
dBm	5	-10	-65	Flag
MHz	107.0	98.0	109.2	
dBm	11	-10	-65	To/From
dBm	6	-10	-65	Flag
	Bendix FA-4165.3A			
MHz	103.7	98.0	109.2	
dBm	4	0	-35	Flag
dBm	6	0	-35	To/From
MHz	103.1	98	109.1	
dBm	1	-10	-75	Flag
dBm	5	-10	-75	To/From

* Signal General Settings for all dBm values of this table.

TABLE 13. INTERMODULATION TEST 6, MARK 12 AND BENDIX CDI DEFLECTION

	SG-1	SG-2	SG-3	Remark
MHz	103.6	98.0	109.2	
dBm*	7	-10	-65	To/From
dBm	5	-10	-65	Flag
MHz	107.0	98.0	109.2	
dBm	11	-10	-65	To/From
dBm	6	-10	-65	Flag
		Bendix FA-4165.3A		
MHz	103.7	98.0	109.2	
dBm	4	0	-35	Flag
dBm	6	0	-35	To/From
MHz	103.1	98	109.1	
dBm	1	-10	-75	Flag
dBm	5	-10	-75	To/From

*Signal General Settings for all dBm values of this table.

TABLE 14. INTERMODULATION TEST, NAV 400 CDI DEFLECTION

Signal Generator	Settings	Comments
SG-1 SG-2	ILS SIM	
90 MHz 102 MHz	109.1	
dBm dBm	dBm	
10 10	-50	Flag F.S. Deflection
5 5	-50	No Deflection
10 10	-50	15 µA Left, 25 µA Right
5 10	-50	10 µA Left, 10 µA Right
0 10	-50	2 µA Left, 9 µA Right
-5 10	-50	0-5 Right
0 5	-50	0-3 Right
0 0	-50	±2 µA
WITH ELT		
5 10	-50	20 µA Left, 25 µA Right
0 10	-50	10 µA Left, 22 µA Right
-5 10	-50	±10 µA
0 5	-50	± 5 µA
0 0	-50	Bias of 2 µA Right

Tables 12 and 13 present the levels of FM signal which will produce a shift in flag condition of "TO" or "FROM". The Bendix in this case is shown to move to a false indication with a strong FM signal.

Finally, table 14 presents the results of tests on the NAV 400 using a strong AM signal. The FM signals must be held at a high level to have significant effect on CDI current.

"Motorboating" sound Interference. A laboratory investigation was accomplished on the motorboating sound prevalent in general aviation type receivers when subjected to multiple commercial FM broadcast environment. Two signal generators were adjusted to frequencies F_a and F_b respectively to provide a third intermodulation product ($F_i = 2F_a - F_b$). Both FM signals from the generators were applied to a Genave Alpha/10 receiver at 0 dBm level and 75 kHz deviation with 1000 Hz modulation. If either a or b frequency was varied to depart from the intermodulation frequency, the intermodulation tone present was being surmounted by a motorboating sound. As the frequency separation from the intermodulation was increased, the tone level decreased and the beat (click) present in the motorboating sound increased in frequency and intensity, then decreased into receiver noise at approximately 200 kHz departure from the original frequency setting. If no modulation was applied, only receiver noise was present.

PREDICTION OF INTERFERENCE. Earlier described laboratory tests have shown that the FM signal levels for intermodulation interference need not be of equal dBm levels. The equation for intermodulation used in this report is as follows:

$$AF_1 + BF_2 - CF_3 = F_i$$

Where:

A, B, and C = coefficients 0 to 3
F_1, F_2, F_3 = radiated interference frequencies
F_i = Interference frequency of intermodulation.

The primary/secondary levels required for each coefficient for a few of the combinations are listed in table 15. These levels place a third criteria, power level, as a function of the coefficient on the area of potential interference. One of the several signals (table 15) must be at a high level (prime) with a signal of approximately -10 dBm for communication receiver input and -20 dBm for a navigation receiver, except in the presence of the interfering ELT when lower levels will produce interference. The other signals, secondary, of the intermodulation combination (table 15) may be 10 to 20 dB lower and produce a significant interference on most low-cost general aviation receivers.

TABLE 15. EXPECTED POWER LEVELS FOR SELECTED COEFFICIENT COMBINATIONS OF INTERMODULATION EQUATION

Intermodulation Equation $AF_1 - BF_2 - CF_3$ = Intermodulation Frequency

Coef. A	Level F_1	Coef. B	Level F_2	Coef. C	Level F_3
2	Prime	0	-	1	Secondary
2	Prime	1	Secondary	2	Prime
1	Prime/Sec	1	Prime/Sec	1	Prime/Sec
3	Prime	0	-	2	Secondary

NOTE: Levels maybe interchanged as a function of harmonic output from an FM station and characteristes of the receiver.

The above information plus an assumption that most FM antennas radiate omnidirectionally has led to the Venn diagram solution of where FM signal combinations might be expected to produce intermodulation interference. For the Venn-type solution, it was necessary to determine the distance at which the FM station signal at receiver input would be attenuated to -10 dBm for communication receivers and -20 dBm for navigation receivers. The above two calculations would be the high level or prime FM signal required for a configuration. Appropriate distances must be calculated for secondary level signals of -20 and -30 dBm in intermodulation combinations. The space loss formula was used to calculate the distances:

$$L_S = 38 + 20 \log d + 20 \log f$$

Where:

d = distance in nmi
f = frequency in MHz

The HP-65 calculator program (appendix A) has been written for FM and TV brute force interference calculation which may be used to determine d of the above equation. When using the calculator, once the program has been entered the calculator may be operated as follows:

Step	Instruction	Keys
1	Initialize	RTN, R/S
2	Enter LS in dB	B
3	Enter frequency of FM in MHz	C
4	Read d in feet	D
5	Read d in nmi	E

The calculation of LS is modified as follows:

$$LS = ERP + |P_r| - L_r \text{ dB}$$

Where:

ERP = Effective radiated power of FM station in dBm
$|P_r|$ = Absolute dBm signal level at receiver i.e., -10, -20, -30

L_r = For NAV antenna: Antenna loss of 3 dB plus 1 dB/MHz below 108 MHz
L_r = For COM antenna: Antenna loss of 10 dB from 108 to 100 MHz plus 2 dB/MHz below 100 MHz

If d is used as the radius of circles, they may be presented as in figure 229. The value of d will vary as a function of frequency due to the antenna response. In figure 230 the shaded areas indicate where the conditions are met for potential interference based on power levels from FM stations A and B, where -10 dBm is the prime signal level and -30 dBm the secondary. In figure 231 the prime level is reduced to -20 dBm while the secondary level is held at -30 dBm. The shaded area again indicates the potential area of interference.

Figure 232 illustrates the Topeka, Kansas, area for which power circles have been drawn around the local FM stations. Based on the required combination of KSWT, KTOP, and KTPK for an intermodulation frequency of 121.7 MHz, the figure should be studied to determine the expected area of interference (crosshatched). Interference should be expected in the area common to that overlayed by the PR = -30 (DCOM) circle of KSWT, the PR = -20 (DCOM) circle of KTPK, and the PR = -20 circle of KTOP. The area defined as common to these three circles would be a conservative prediction of interference area for communication receivers. Recorded data for Topeka indicated that the predictions was substantially correct. Within the area, the effect of antenna radiation lobes causes the interference to appear to be intermittent, depending on the course the aircraft flying through the area. The duration of interference is frequently only a few seconds, which reflects the lobe condition of radiation.

Not all areas of radiation may be predicted by the described technique. As described in NAFEC Technical Letter Report, NA-77-41-LR, "High Power FM Station Interference to VHF Avionics, Topika, Kansas," radiation levels from high-gain FM antennas may at times far exceed the level calculated from the effective-radiated power of the FM station and the assumption of uniform omnidirectional radiation due to reflections and lobing in the airspace. High-gain FM station antennas are usually designed to radiate a pattern no more than $\pm 10°$ from the horizontal. However, based on flight test data, high-level signals are usually measured directly above FM antennas.

Loss of Sensitivity. The laboratory tests conducted with single FM signals into the receivers showed a loss of sensitivity of as much as 10 dB for high-level FM signal inputs. The loss should not, however, adversely effect reception in the terminal areas where signal levels are normally expected to be greater than -75 dBm unless there is an intermodulation frequency present due

to the presence of appropriate frequencies. There would not be any audible interference as a result of the single high-level FM signal. Multiple FM signals at high levels result in sensitivity loss equivalent to single signals.

Emergency Locator Transmitter Effects. The adverse effect of the ELT used in laboratory tests and during the flights tests is evident in much of the data presented. The level of FM signal required to cause interference from the ELT is at a minimum between -5 and -0 dBm. Below the -5 dBm level, the ELT ceases to adversely affect its environment. Solutions to the ELT problem have not been considered. Appropriate action to correct the problem is necessary as the ELT is a unit covered by a Technical Standard Order (TSO).

Brute Force Interference. One type of "brute-force" interference is a condition which results from the proximity of the FM band and the ILS band. The FM frequencies extends from 88 MHz to 108 MHz where it interferes with the low end of the ILS band. This type of interference will most often occur only if the separation is a few hundred kHz, thus, it is present only at the (low end) of the navigation band. The FM interference is present due to radiation of on-frequency power within the FCC authorized levels. Proper frequency engineering will prevent authorization of this condition. The conforming FM emission is: "Between 120 and 240 kHz removed from the carrier, any emission must be at least 25 dB below the unmodulated carrier. Between 240 and 600 kHz removed from the carrier, any emission must be at least 35 dB below the unmodulated carrier. Any emission removed from the carrier by more than 600 kHz must be at least 80 dB below the level of the unmodulated carrier or at least $43 + 10 \log_{10} P$ whichever is the lesser attenuation ('Reference Data for Radio Engineers,' ITT, Fifth Edition)."

A second type of "brute-force" interference is where the strength of signal is the critical parameter. Protection against this form of interference is particularly critical for navigation receivers. The protection procedure should establish distance from the FAA facility within which interference levels should not exist. The level must consider the standards for receiver performance. The scope of the project did not seek to establish such a level.

Finally, no brute force audio modulation was observed during laboratory tests. The maximum input which could be achieved in most cases was approximately +5 dBm. Rarely, during flight testing, were FM signal levels on the spectrum analyzer observed to exceed 0 dBm.

CONCLUSIONS

1. Intermodulation interference from FM stations was found to be present at most locations where flight testing was conducted at low altitude. The locations were in or near cities which had several high-power FM stations serving the cities. The interference was most severe near major FM radiation areas used by several stations. The interference recorded affected both communication and navigation receivers.

2. A 10 dB increase of rejection in the avionic receivers to FM signals would nearly eliminate intermodulation interference.

3. Receiver sensitivity and selectivity are significantly reduced by high-power FM signals.

4. The presence of an FM signal at the prime level in a terminal area diminishes the number of channels in the VHF avionics band available for avionic use which will be free of interference to all but high-performance avionics.

5. Due to avionic antenna frequency response to the FM band, avionic receivers are less subject to interference of FM signals near 88 MHz.

6. Intermodulation interference at the high end of the VHF communications band is less frequent and less severe based on receiver response to laboratory interference tests.

7. Expected intermodulation interference can be effectively located through the use of Venn diagram circles whose radii are based on receiver input power level. However, interference may occur when reflections and radiation characteristics of an FM antenna cause an FM signal to be present at an intermodulation power level even though calculated radius based on ERP would indicate that it should be beyond the range of interference level.

8. Certain ELTs increase the amount of intermodulation interference from FM stations to VHF avionics due to diode action on FM signals within the ELT and reradiation of the modified signals to avionic receivers via the ELT antenna.

RECOMMENDATIONS

1. Protect from "prime" level FM signals the ILS and VOR approaches to airports and also those air spaces near airports where communication intermodulation interference is considered hazardous to general aviation. A "prime" level signal in these areas will adversely affect most general aviation avionic receivers and establish the conditions which will cause intermodulation with the presence of an intermodulation "secondary" FM signal.

2. Implement a procedure for analysis of expected FM station interference from proposed FCC action. The procedure should include both "brute force" considerations as well as intermodulation prediction based on the Venn diagram approach of this report, in order to adequately protect the communication and navigation frequencies of the VHF avionic band.

3. Establish a flight test program by Flight Standards Service to determine the FM spectrum signature and power level at airports which may be subject to FM interference. Current information on FM airspace power levels is inadequate to perform frequency management assignments free of FM intermodulation interference (particularly for navigation receivers).

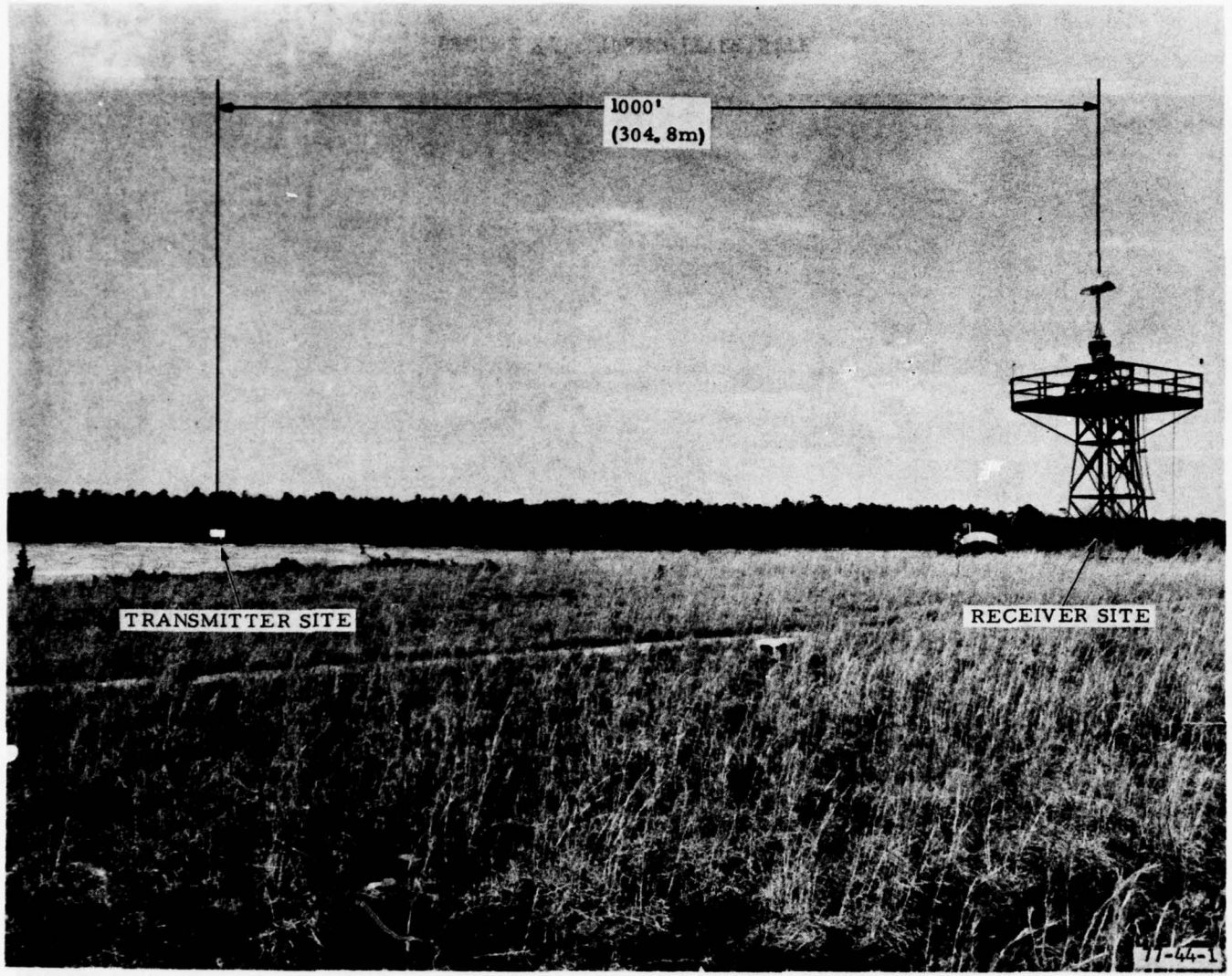


FIGURE 1. ANTENNA TEST RANGE

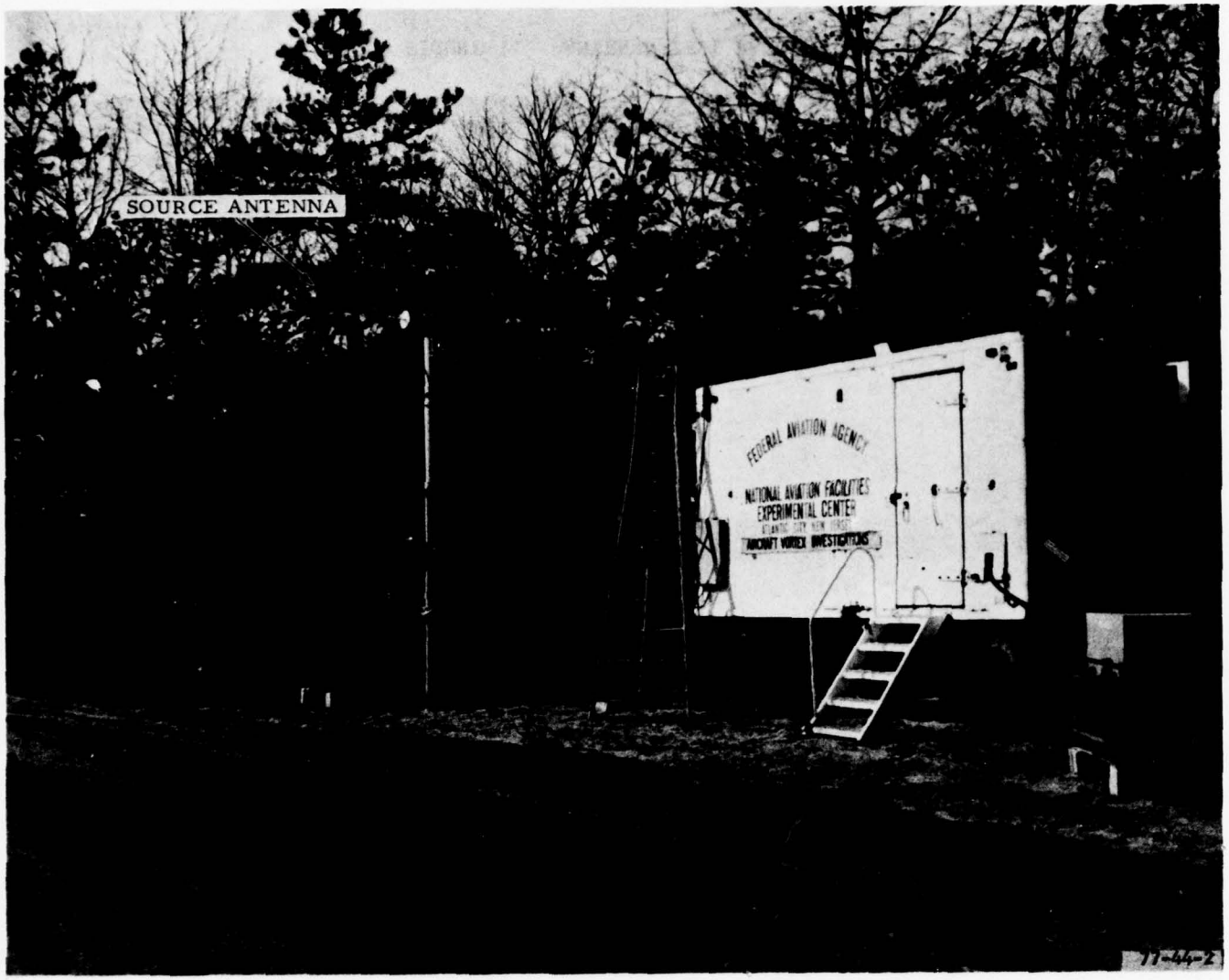


FIGURE 2. TRANSMITTER SITE

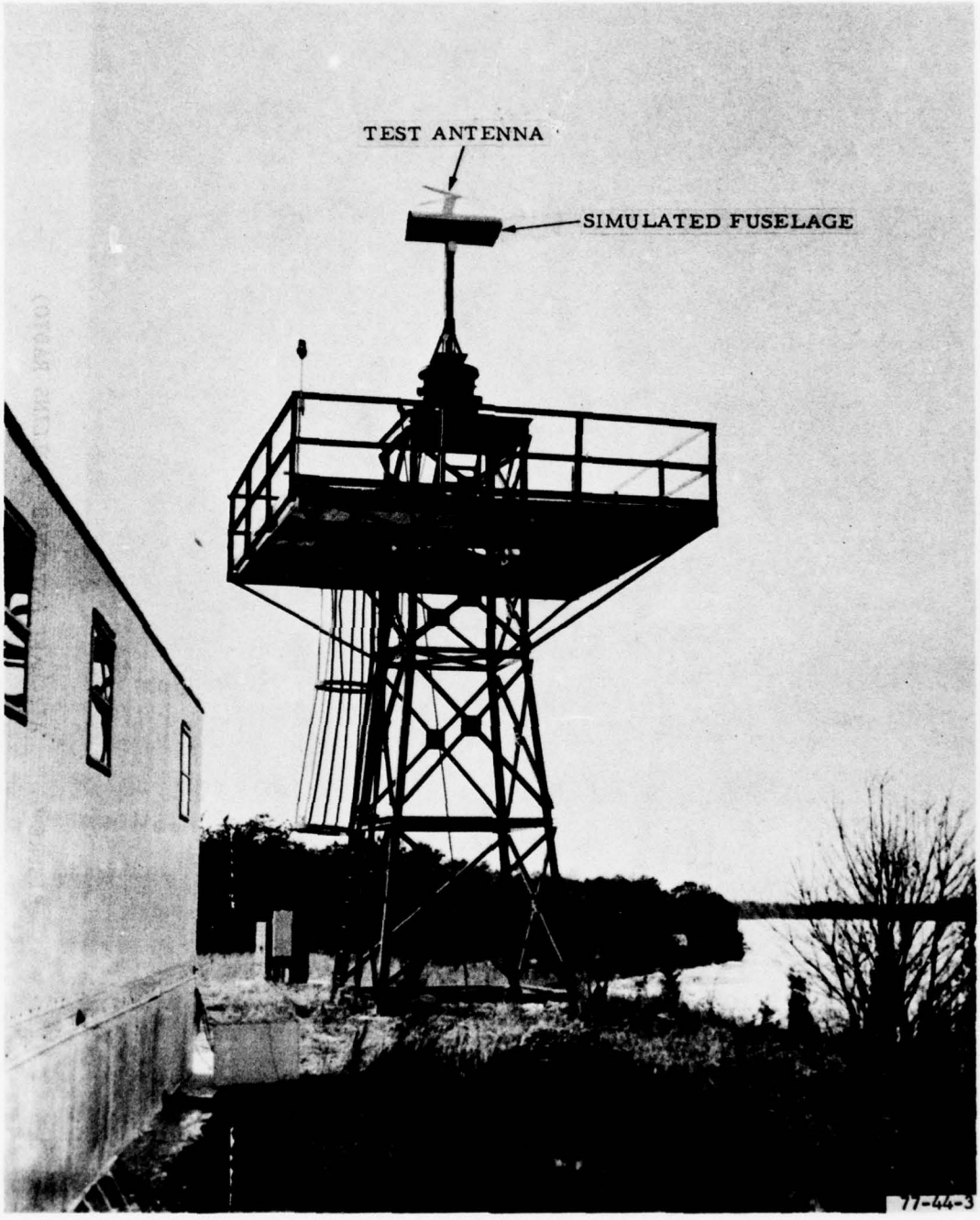


FIGURE 3. RECEIVER SITE

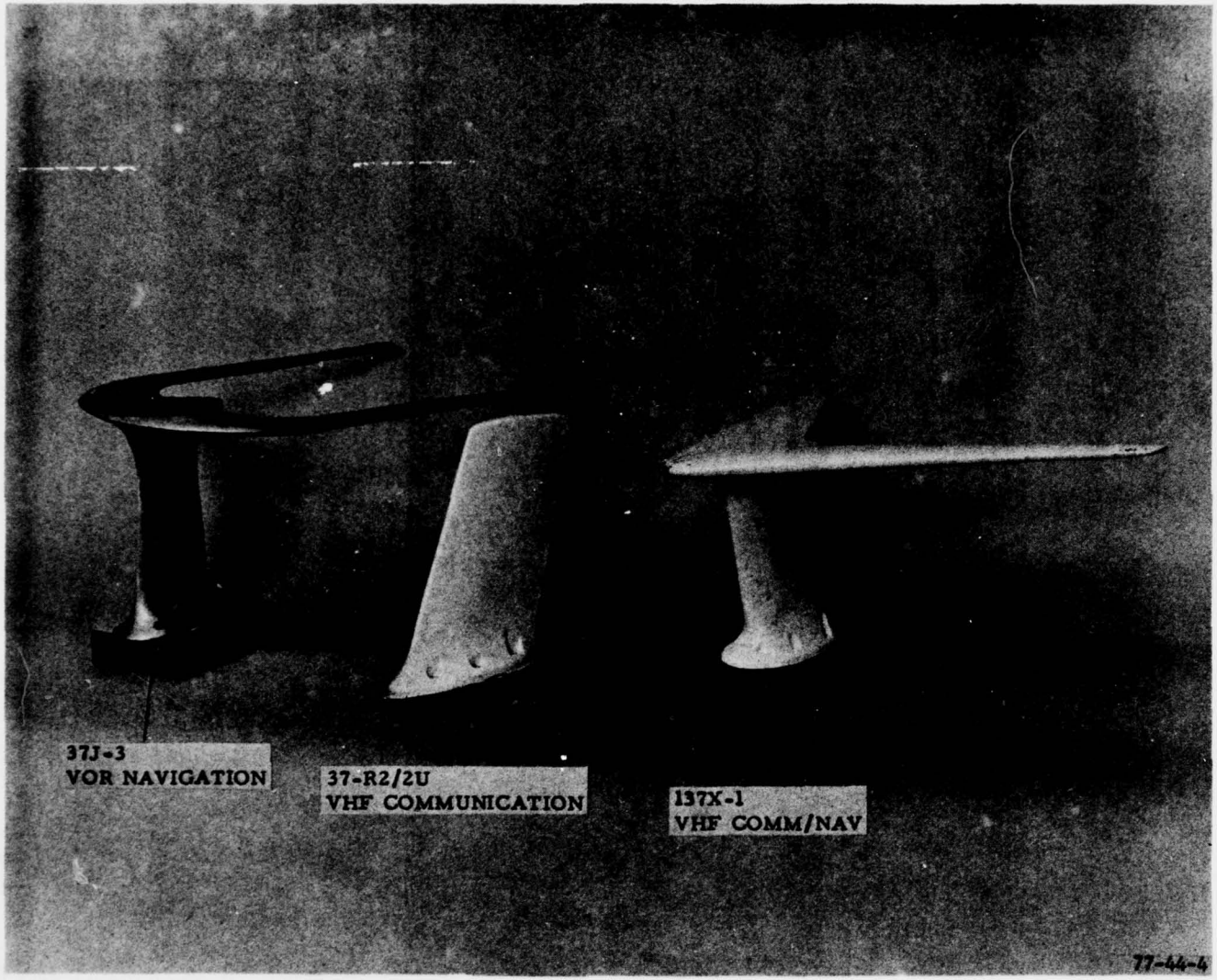


FIGURE 4. AIRCRAFT ANTENNAS (COLLINS RADIO)

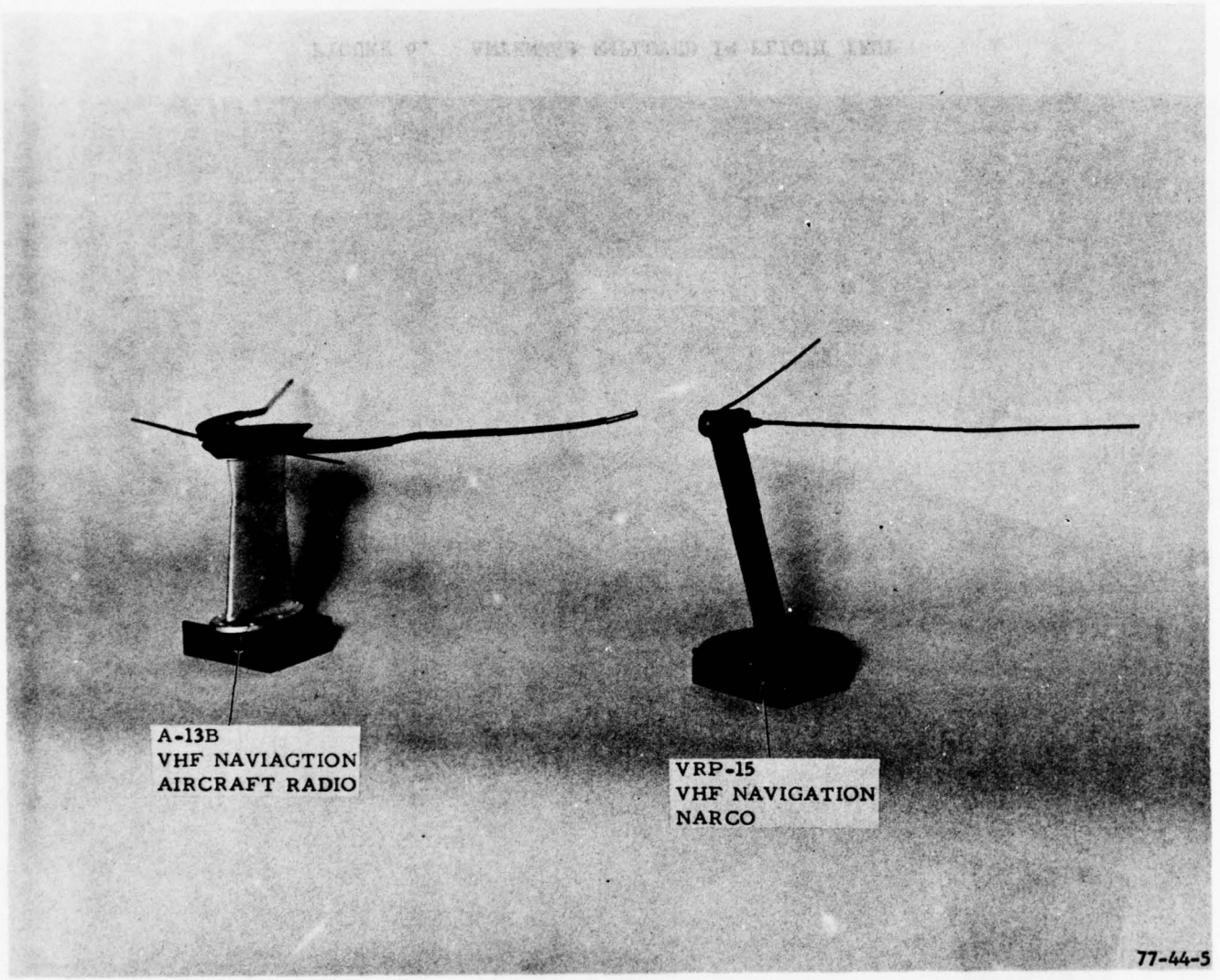


FIGURE 5. AIRCRAFT ANTENNAS (GENERAL AVIATION)

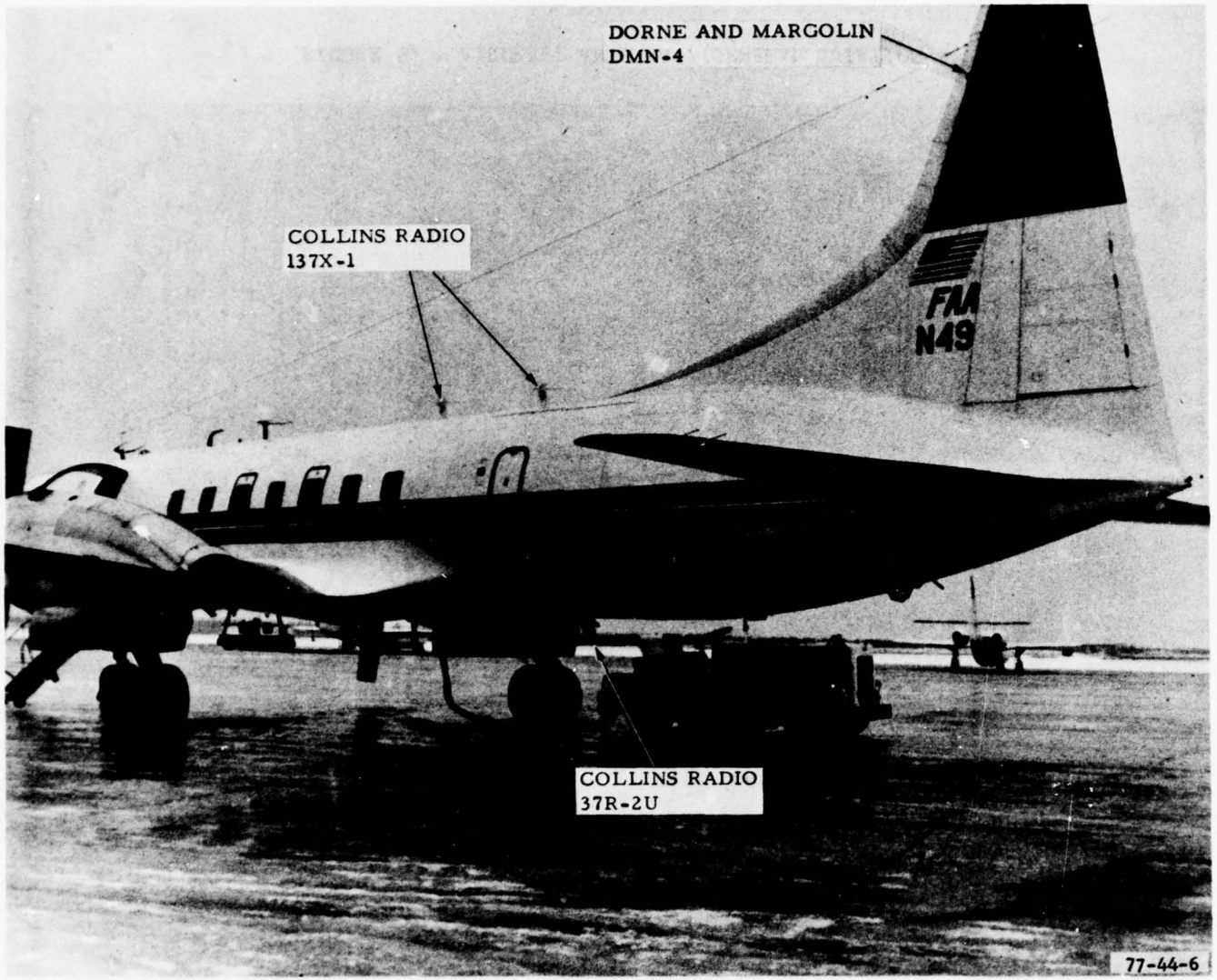


FIGURE 6. ANTENNAS EMPLOYED IN FLIGHT TEST

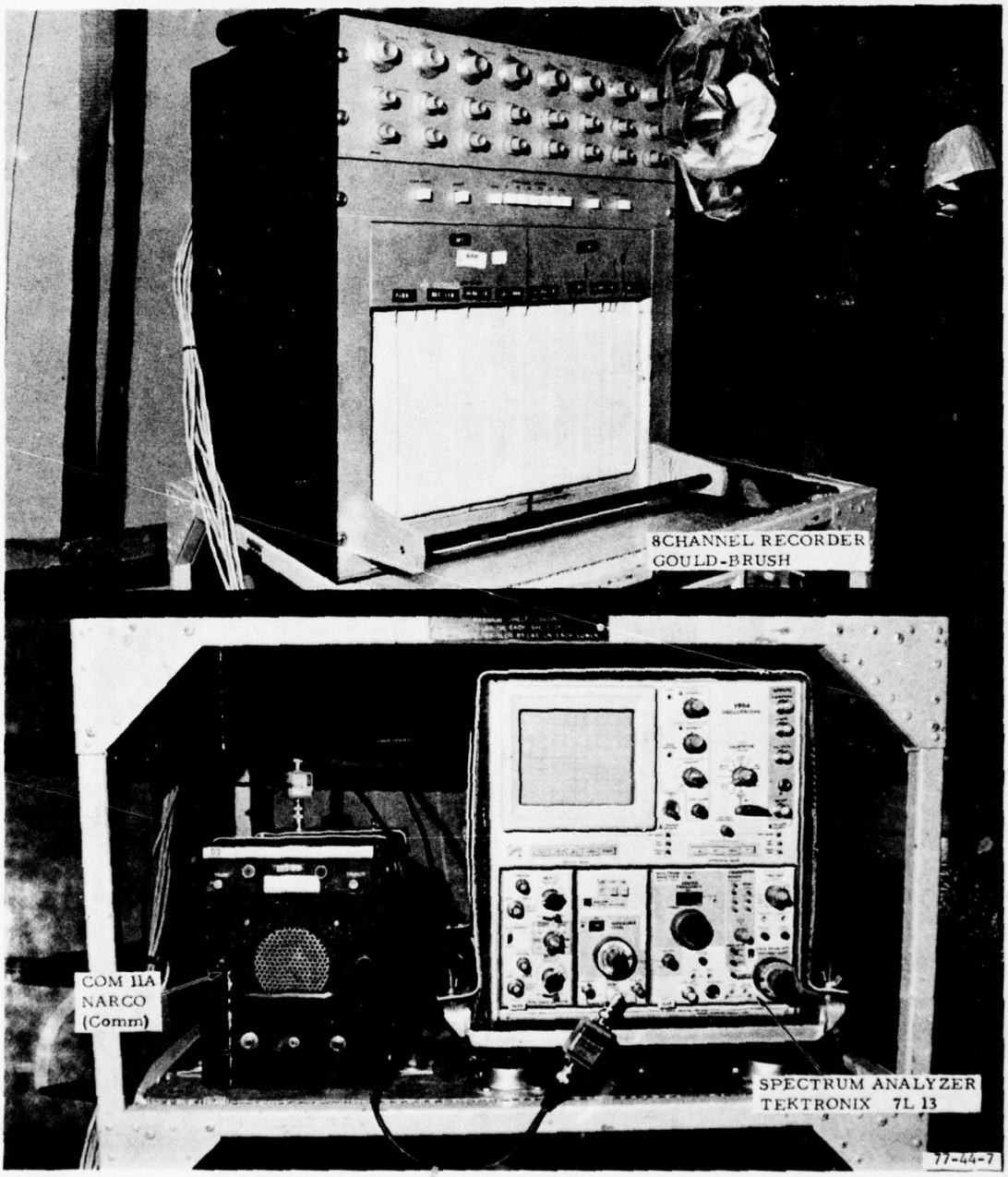


FIGURE 7. INTERFERENCE MONITORING EQUIPMENT

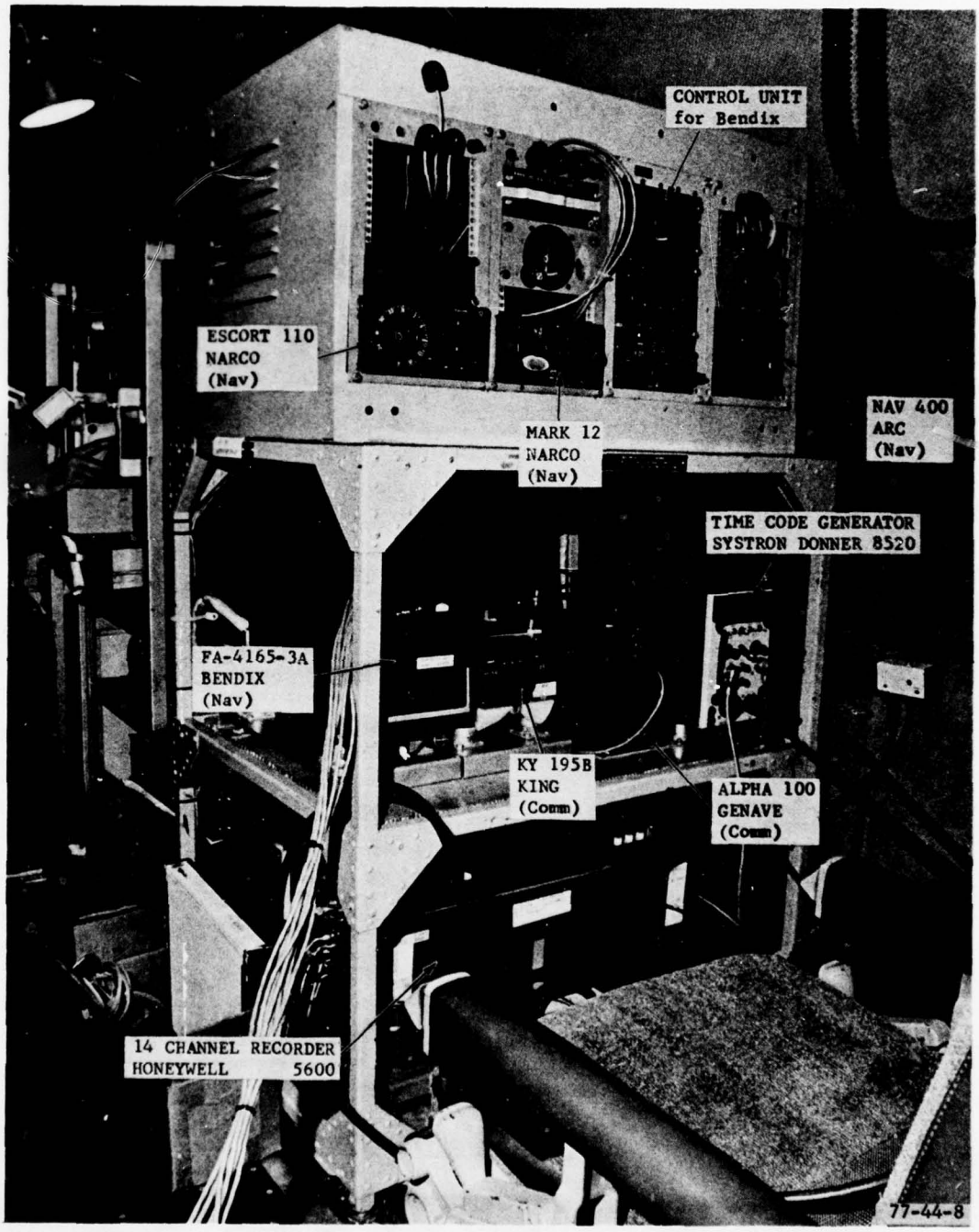


FIGURE 8. INTERFERENCE TEST RECEIVERS

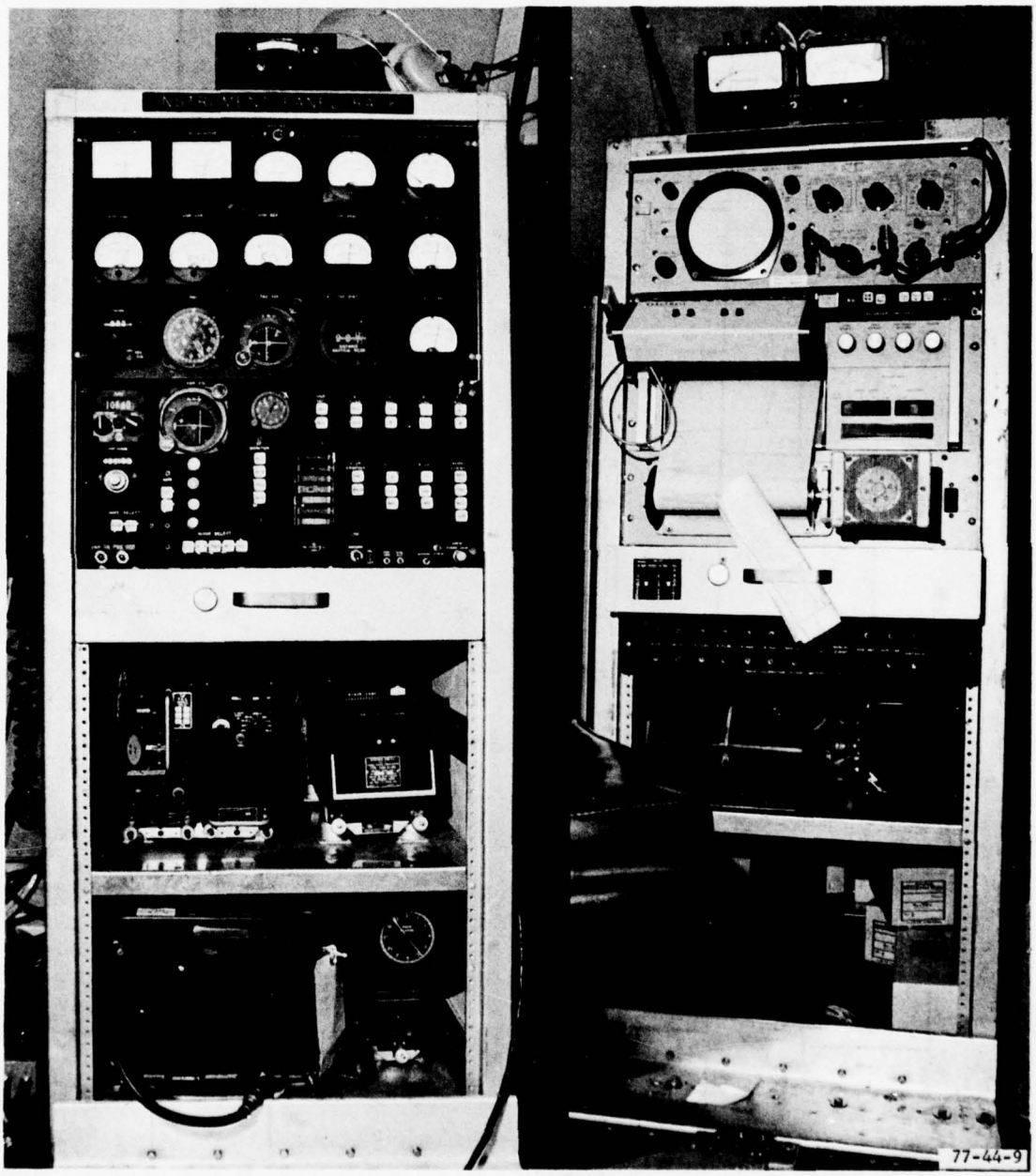


FIGURE 9. STANDARD FLIGHT INSPECTION CONSOLES

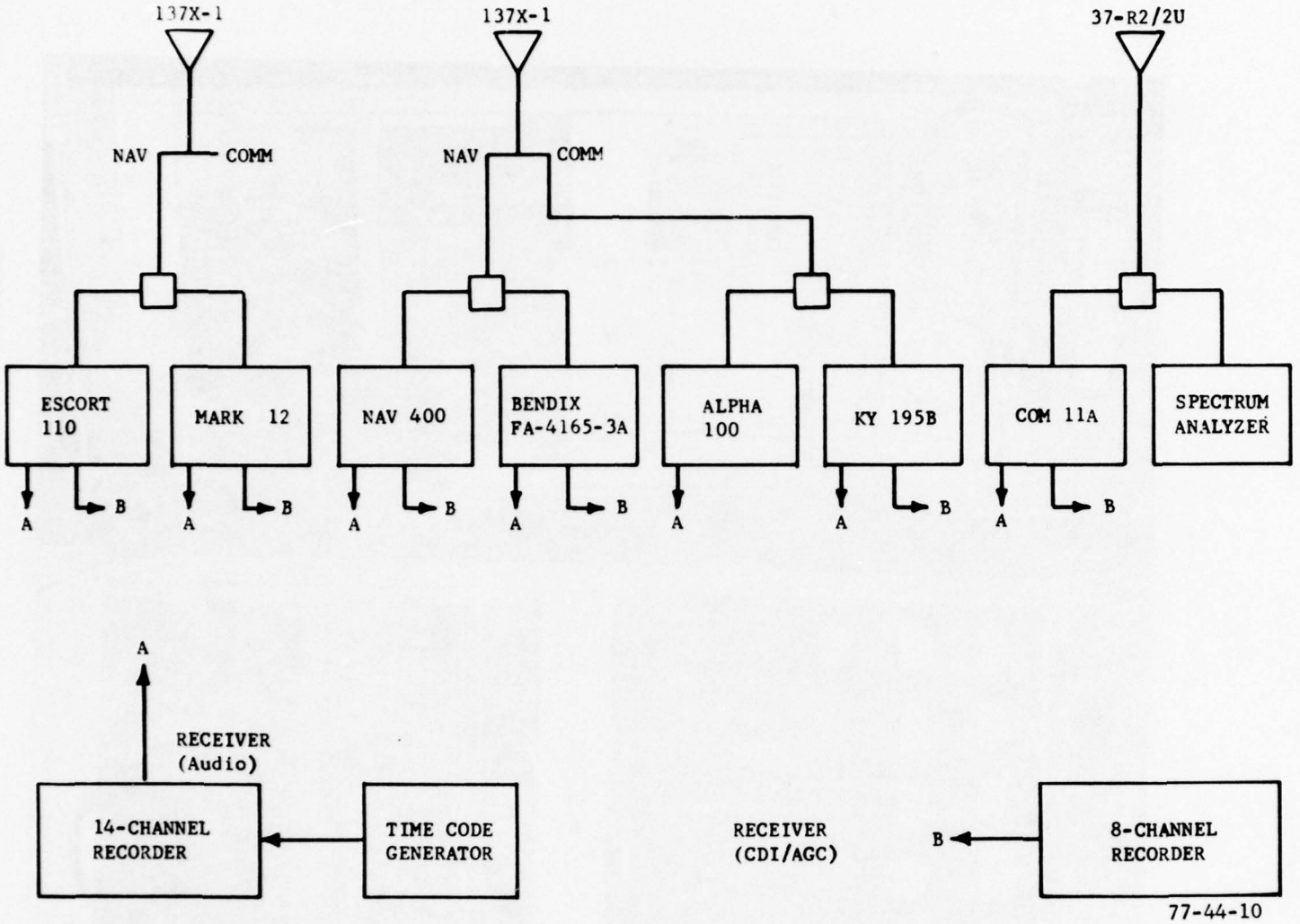


FIGURE 10. RECEIVER CONFIGURATION IN CONVAIR 580 AIRCRAFT

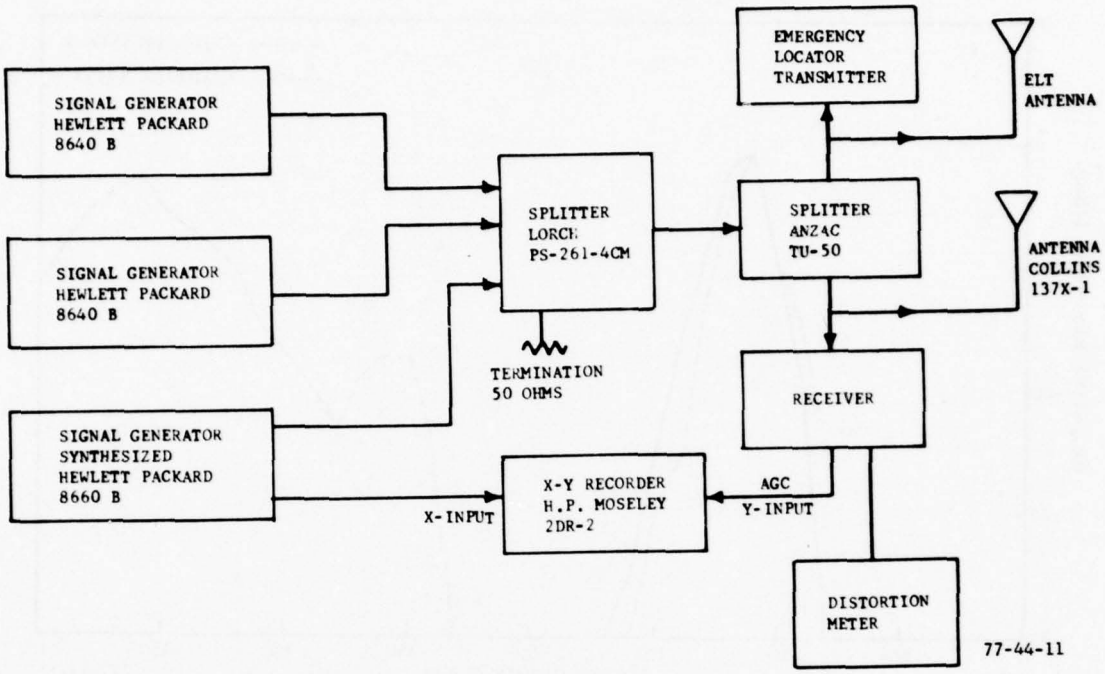


FIGURE 11. LABORATORY TEST CONFIGURATION

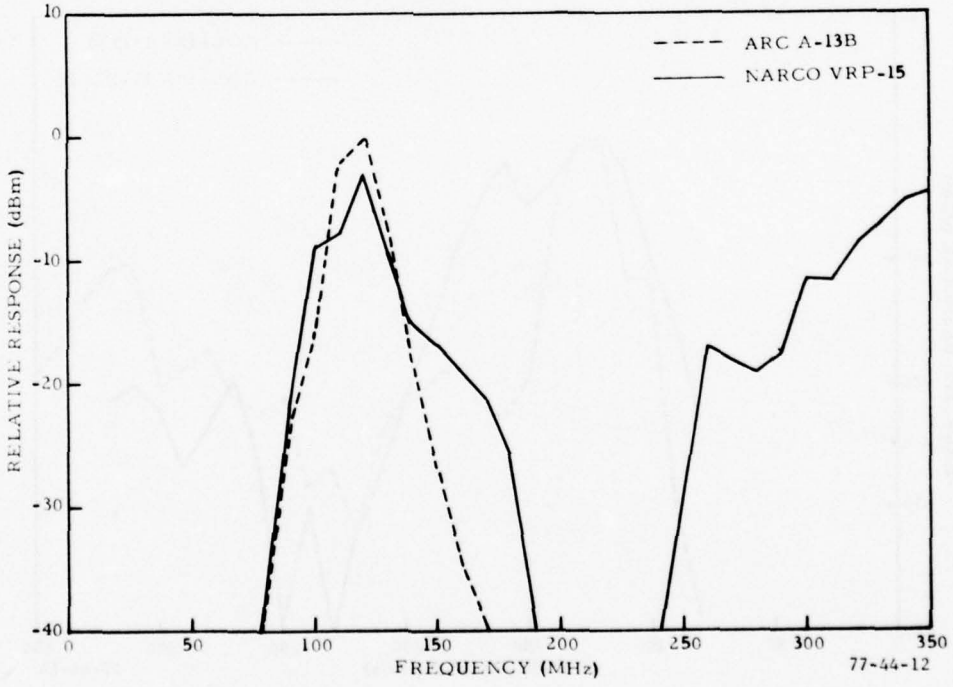


FIGURE 12. FREQUENCY RESPONSE OF NAVIGATION AIRCRAFT ANTENNAS (GENERAL AVIATION)

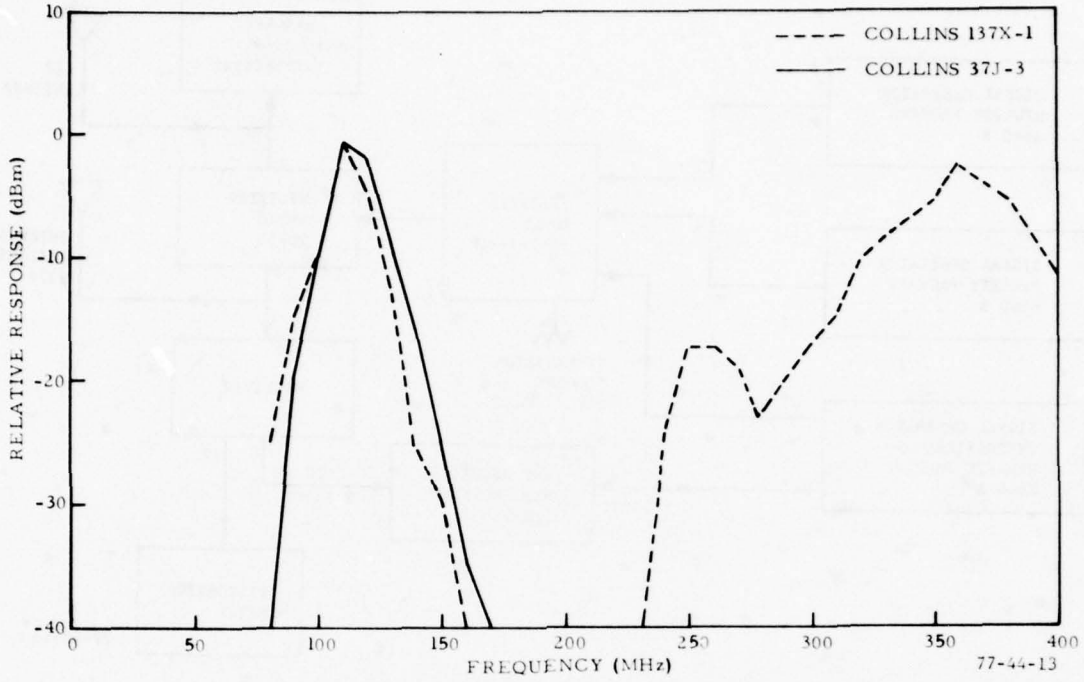


FIGURE 13. FREQUENCY RESPONSE OF NAVIGATION AIRCRAFT ANTENNAS (COMMERCIAL)

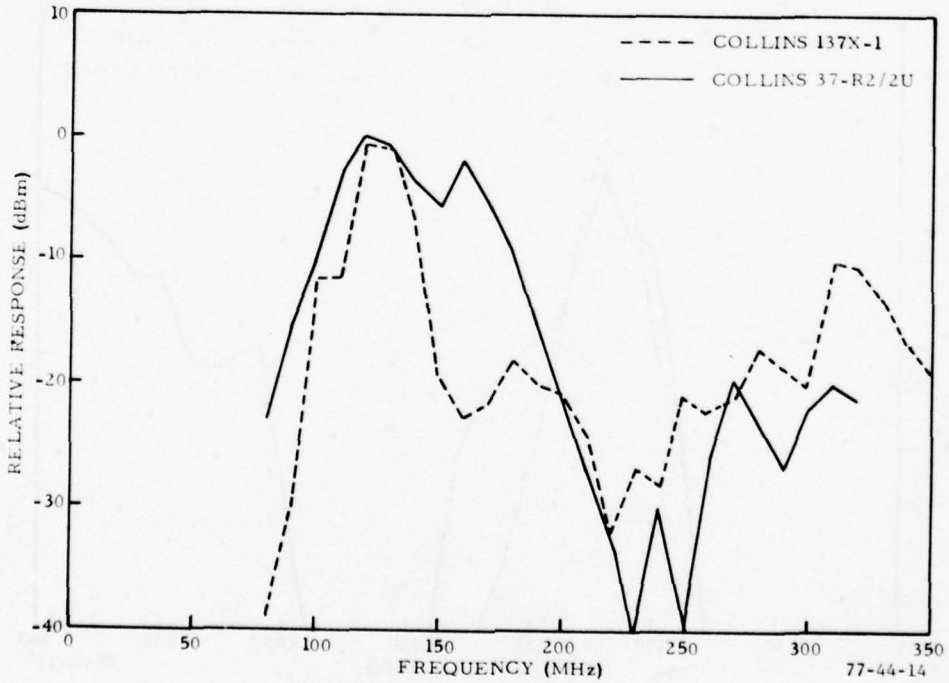


FIGURE 14. FREQUENCY RESPONSE OF COMMUNICATION AIRCRAFT ANTENNAS (COMMERCIAL)

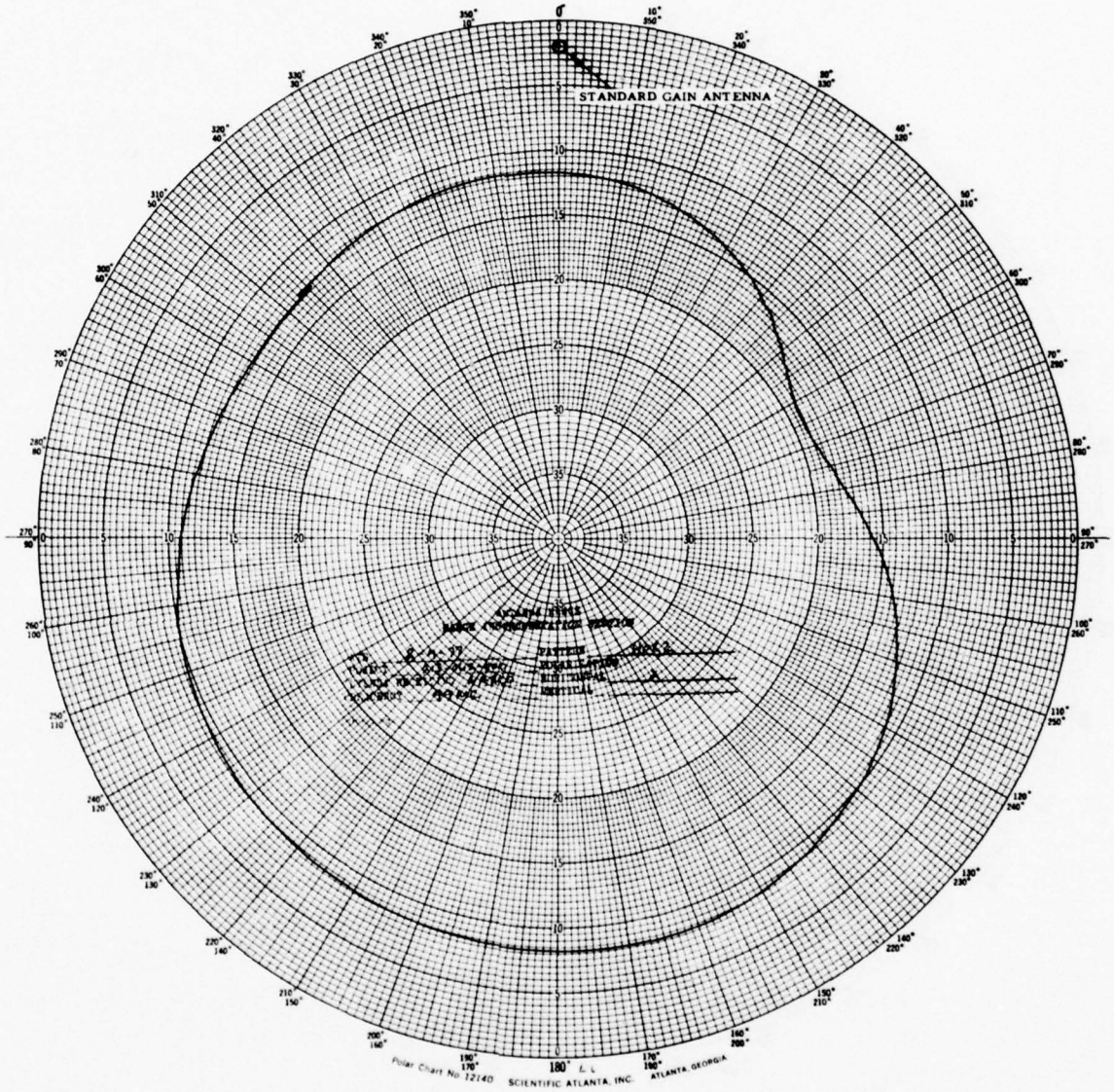


FIGURE 15. HORIZONTAL PATTERN OF NARCO VRP-15 ANTENNA 99 MHz HORIZONTALLY POLARIZED SOURCE

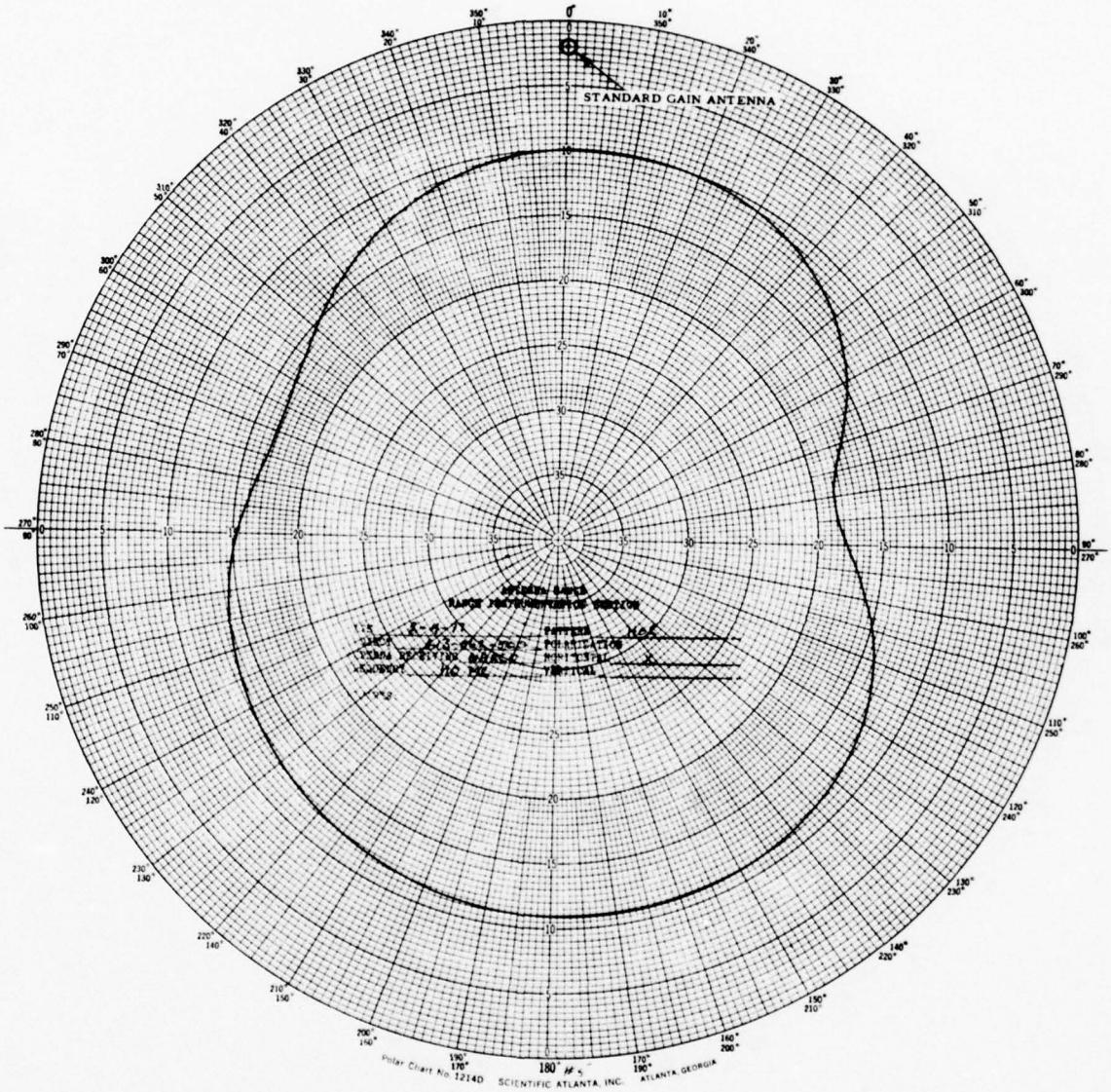


FIGURE 16. HORIZONTAL PATTERN OF NARCO VRP-15 ANTENNA 110 MHz HORIZONTALLY POLARIZED SOURCE

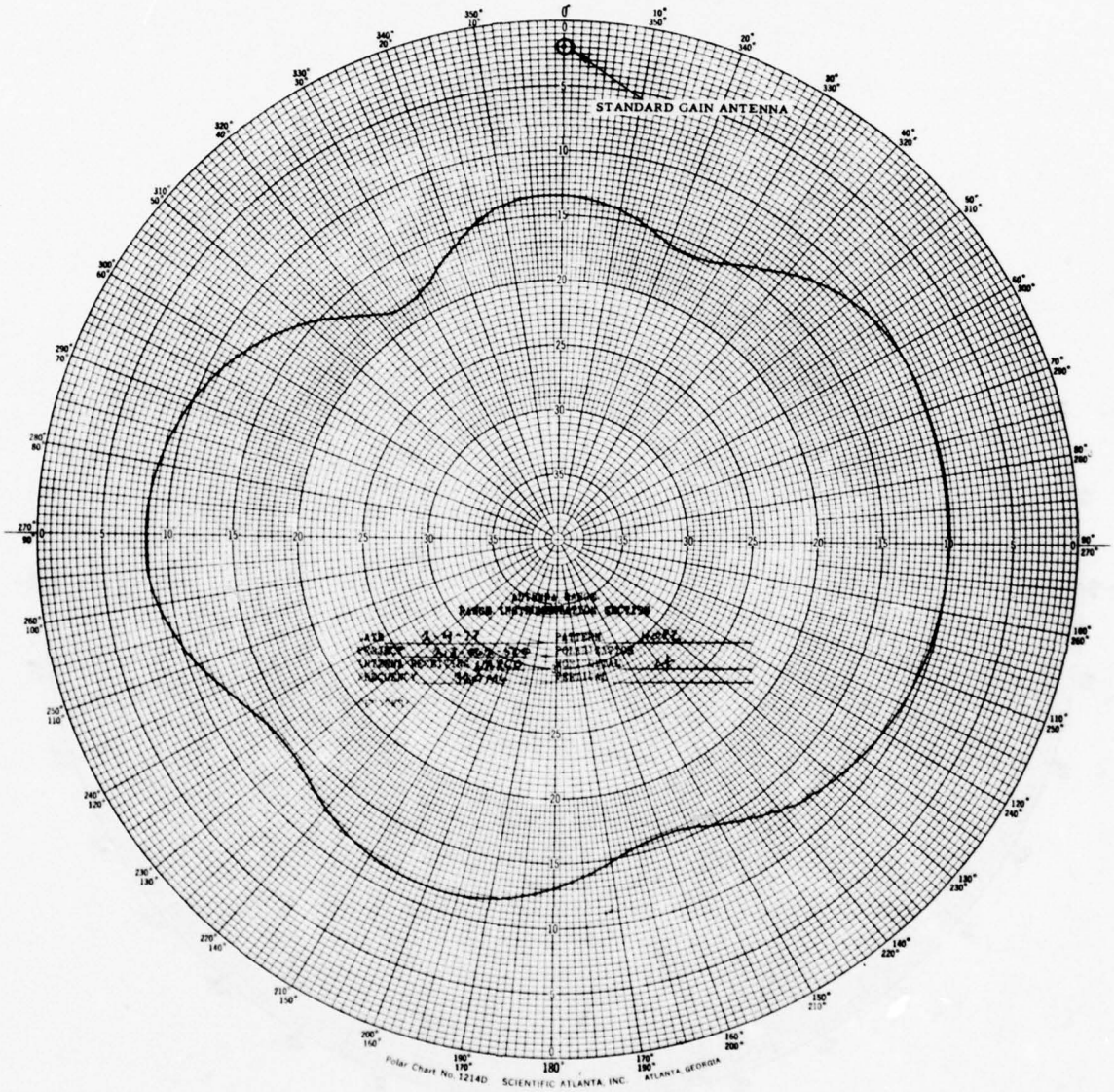


FIGURE 17. HORIZONTAL PATTERN OF NARCO VRP-15 ANTENNA 320 MHz HORIZONTALLY POLARIZED SOURCE

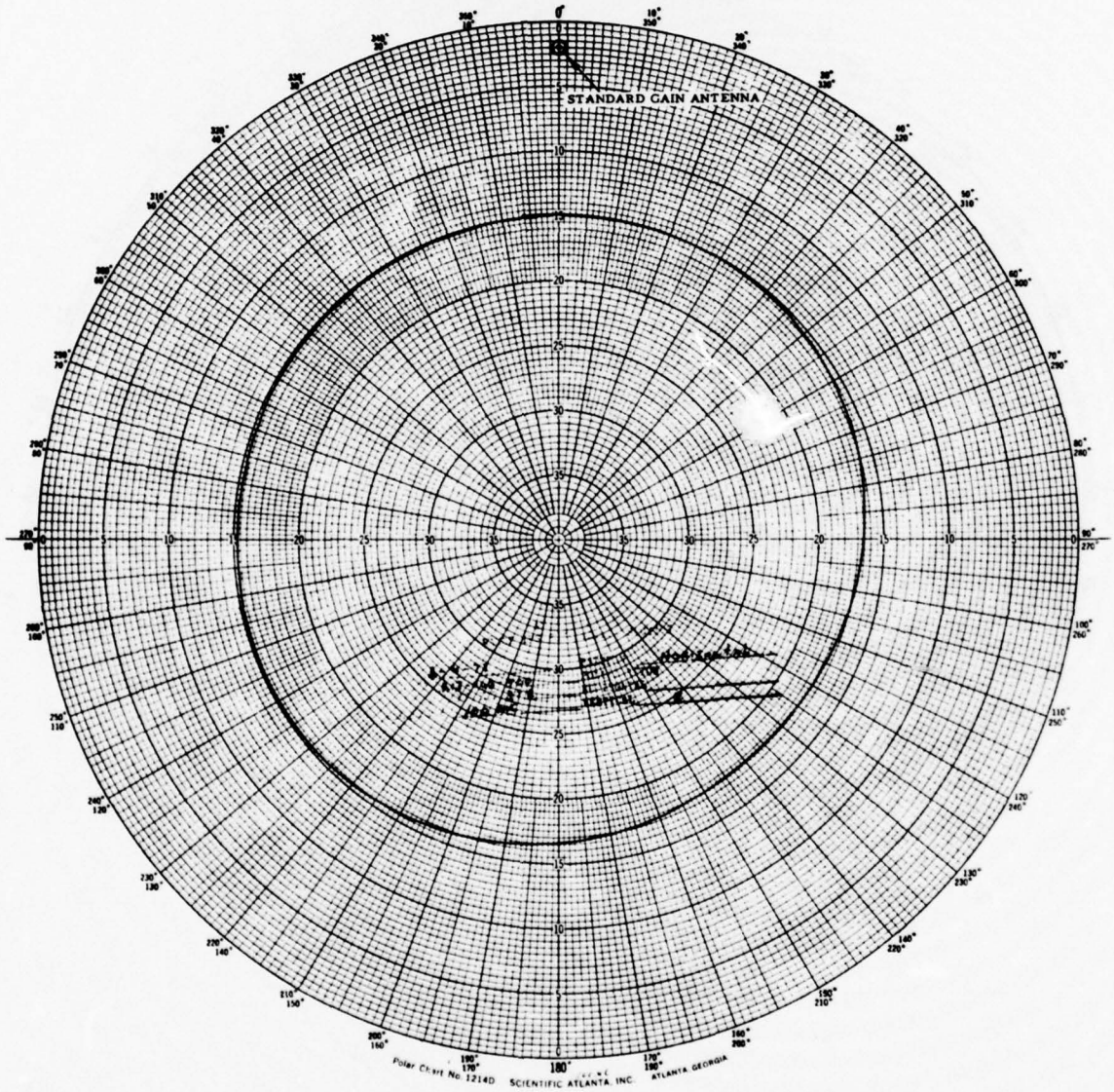


FIGURE 18. HORIZONTAL PATTERN OF COLLINS 37R-2U ANTENNA 100 MHz VERTICALLY POLARIZED SOURCE

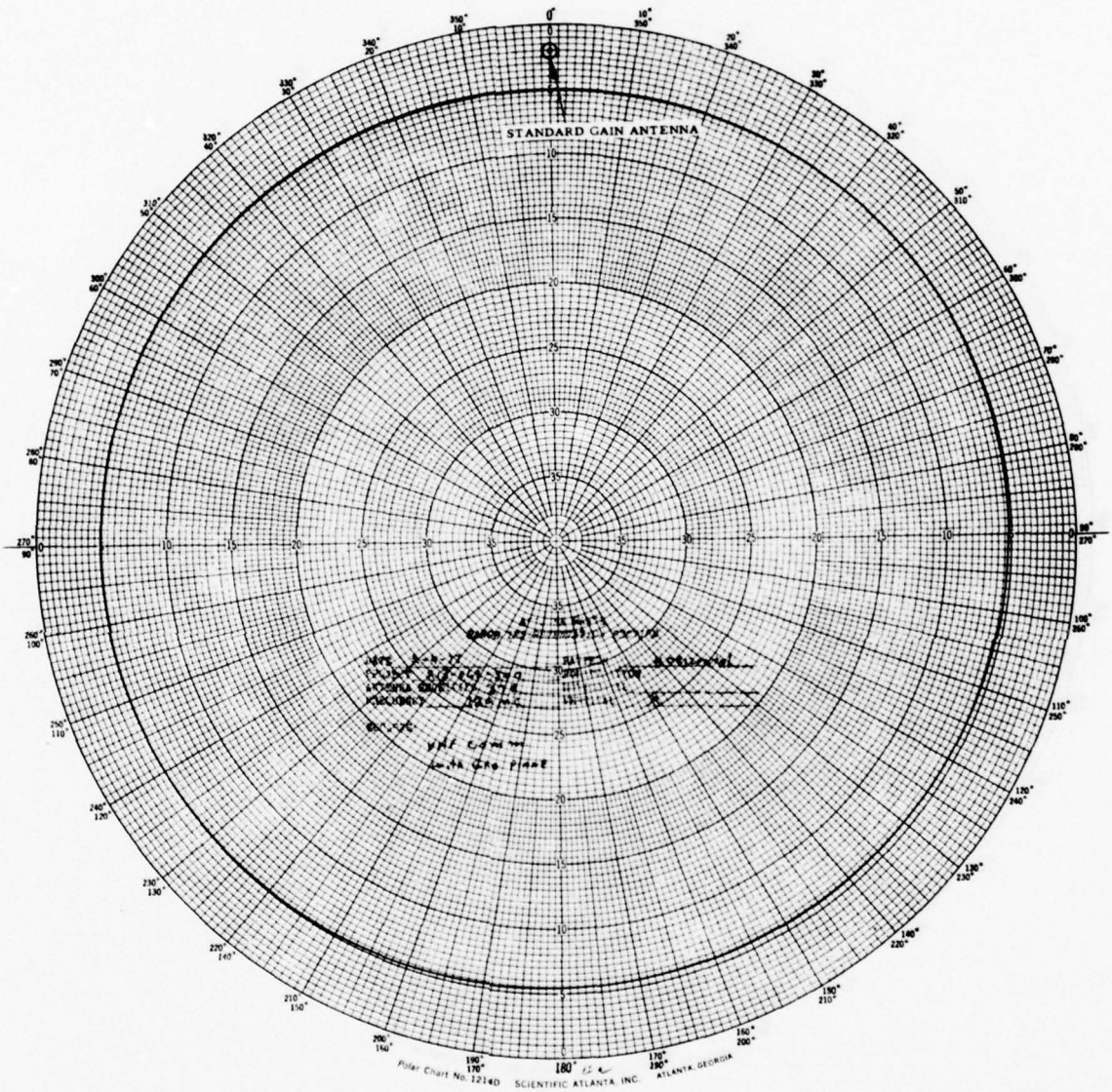


FIGURE 19. HORIZONTAL PATTERN OF COLLINS 37R-2U ANTENNA 120 MHz VERTICALLY POLARIZED SOURCE

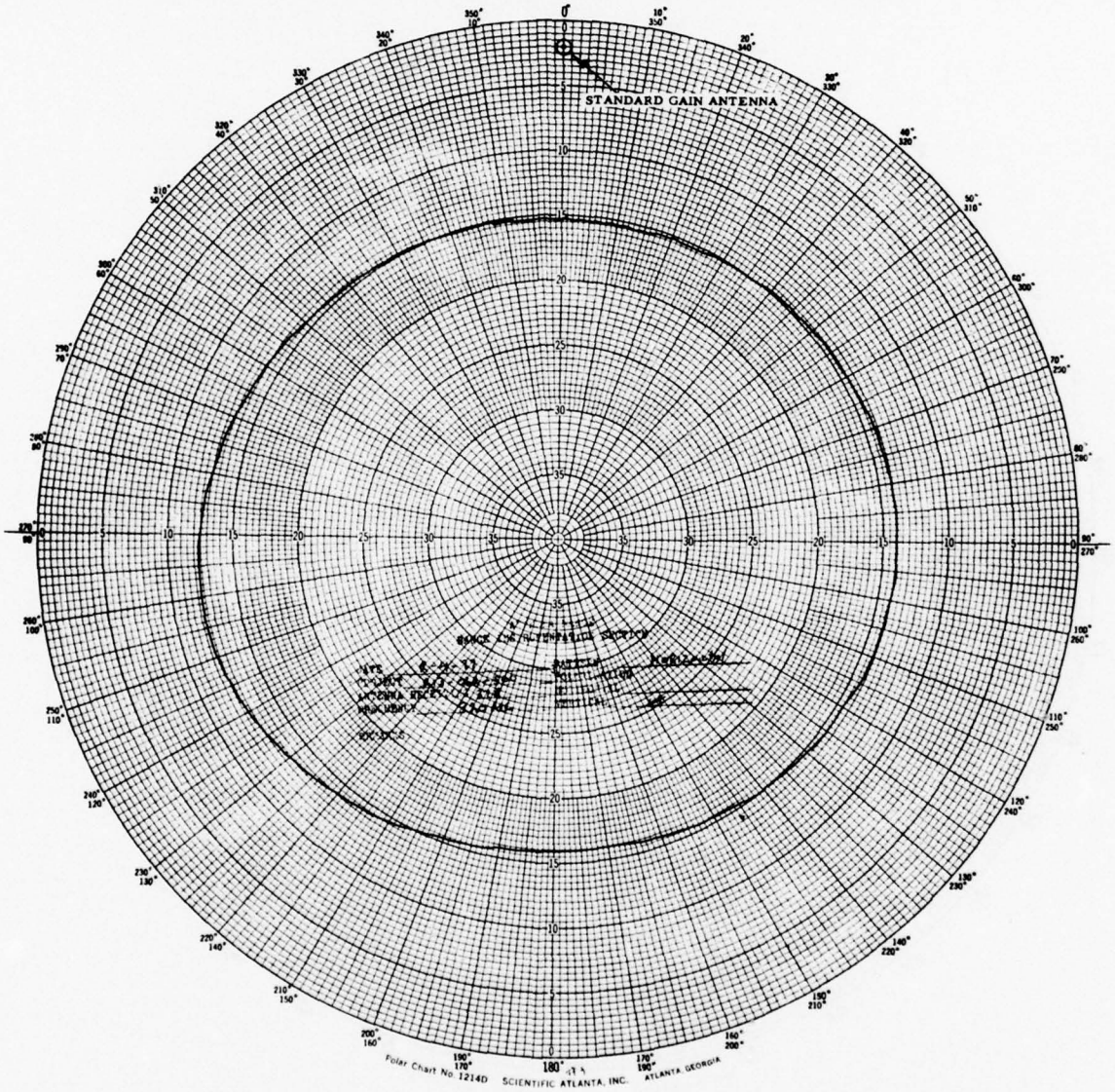


FIGURE 20. HORIZONTAL PATTERN OF COLLINS 37R-2U ANTENNA 320 MHz VERTICALLY POLARIZED SOURCE

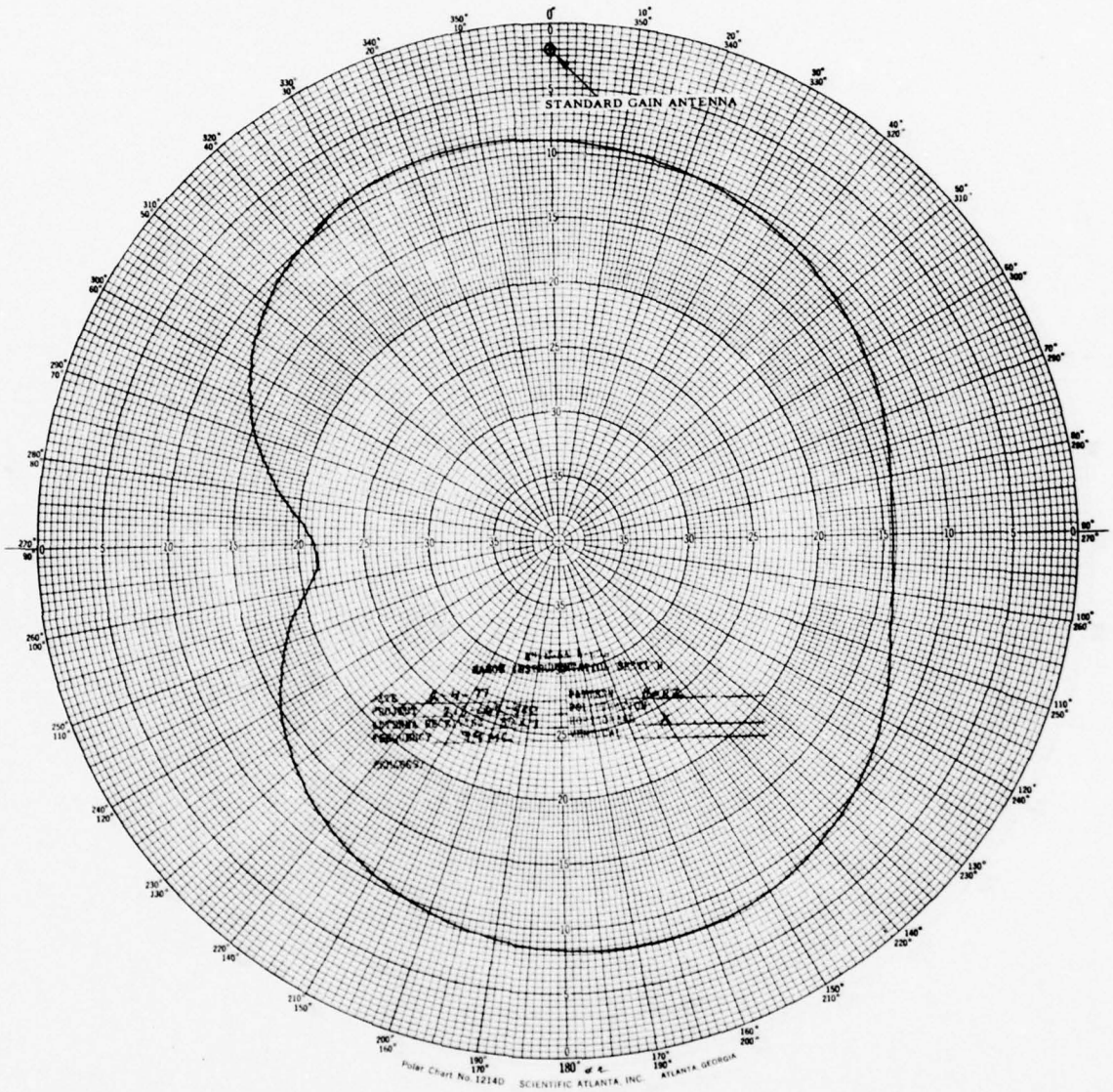


FIGURE 21. HORIZONTAL PATTERN OF COLLINS 137X-1 ANTENNA 99 MHz HORIZONTALLY POLARIZED SOURCE

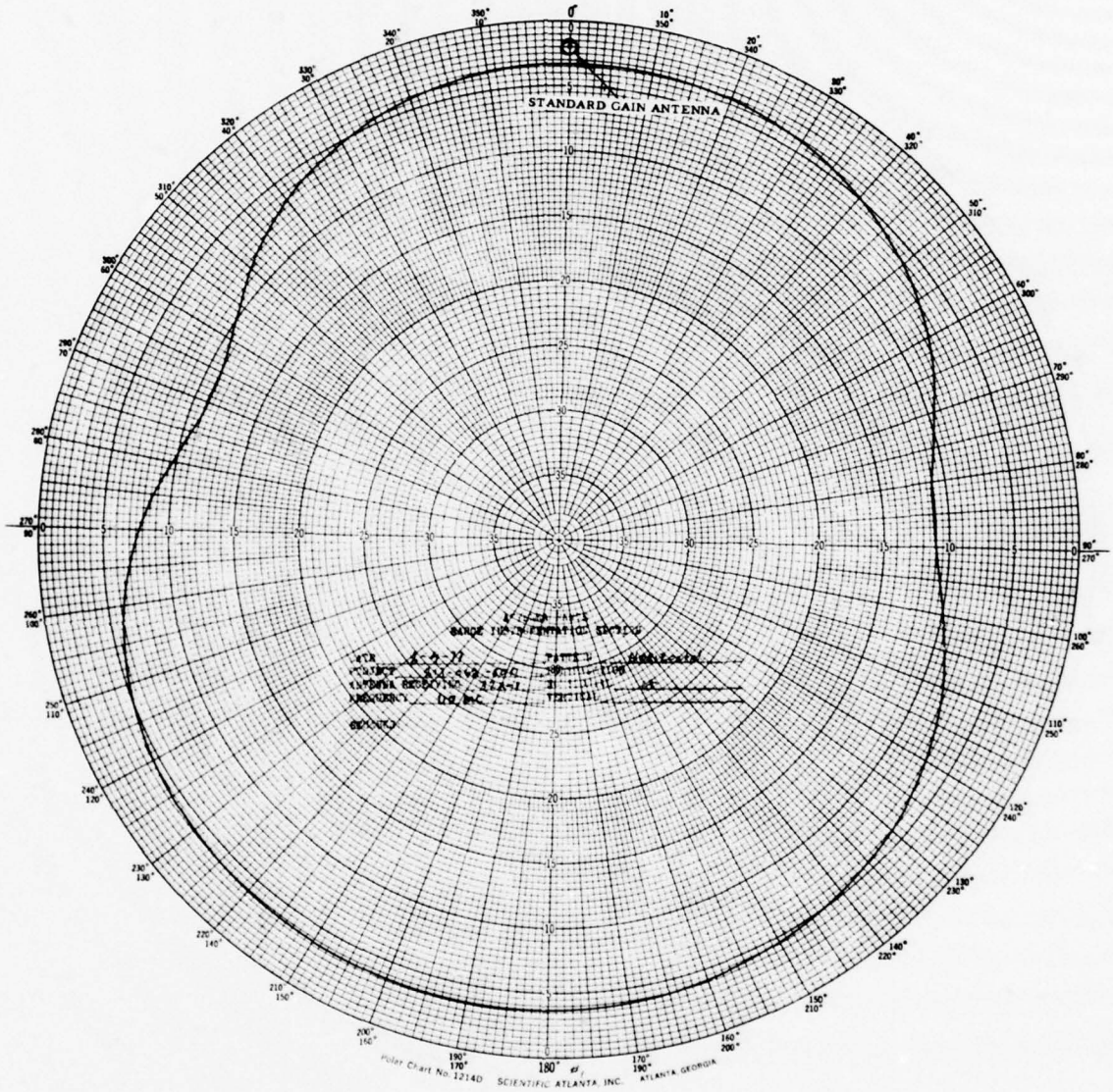


FIGURE 22. HORIZONTAL PATTERN OF COLLINS 137X-1 ANTENNA 110 MHz HORIZONTALLY POLARIZED SOURCE

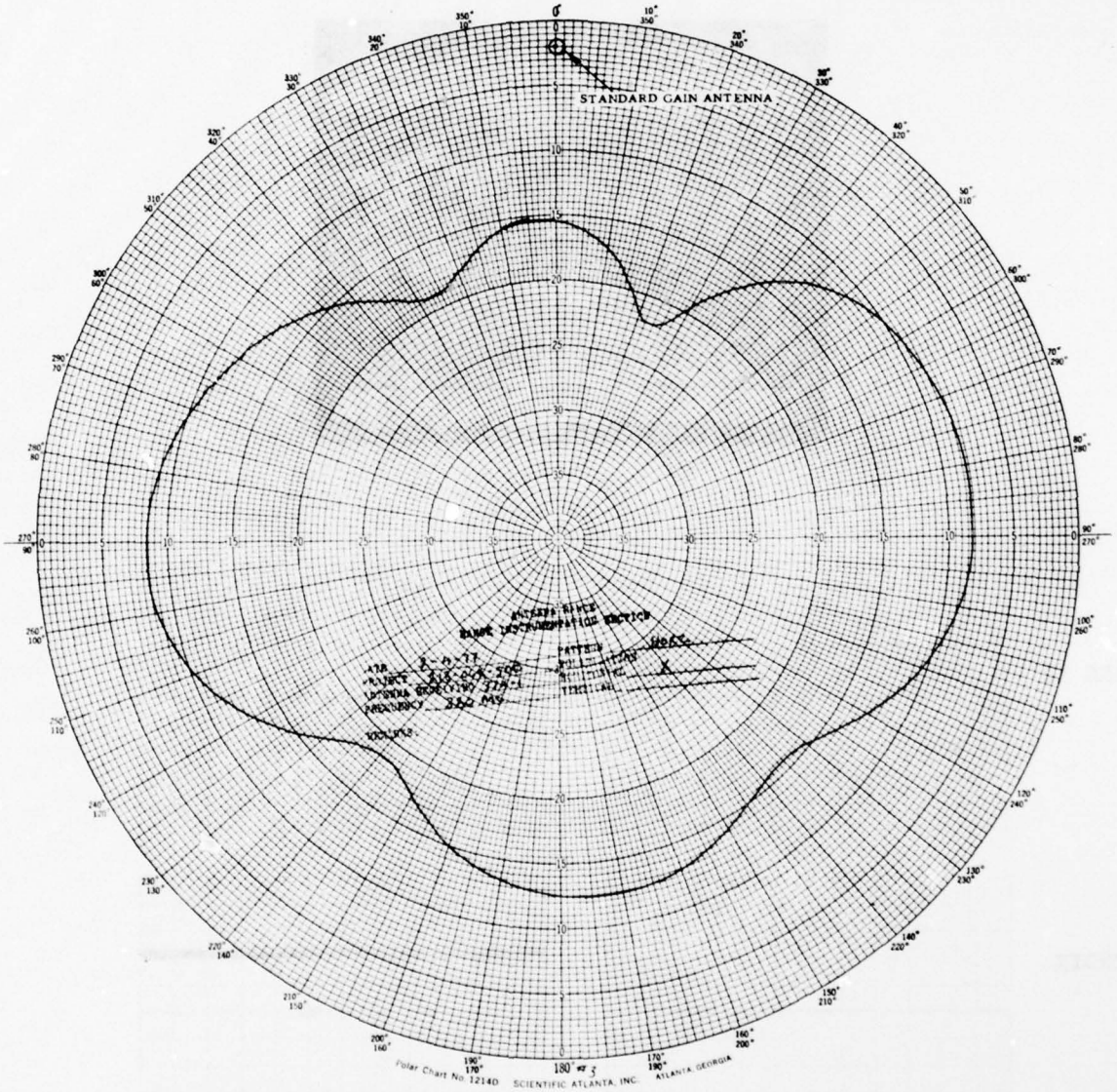


FIGURE 23. HORIZONTAL PATTERN OF COLLINS 137X-1 ANTENNA 320 MHz HORIZONTALLY POLARIZED SOURCE

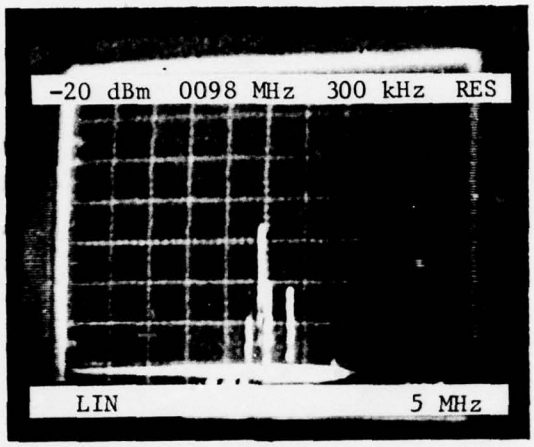
LOCATION: Rwy 4, 6 nmi from threshold

AUDIO INTERFERENCES:

BENDIX- None

MARK 12- None

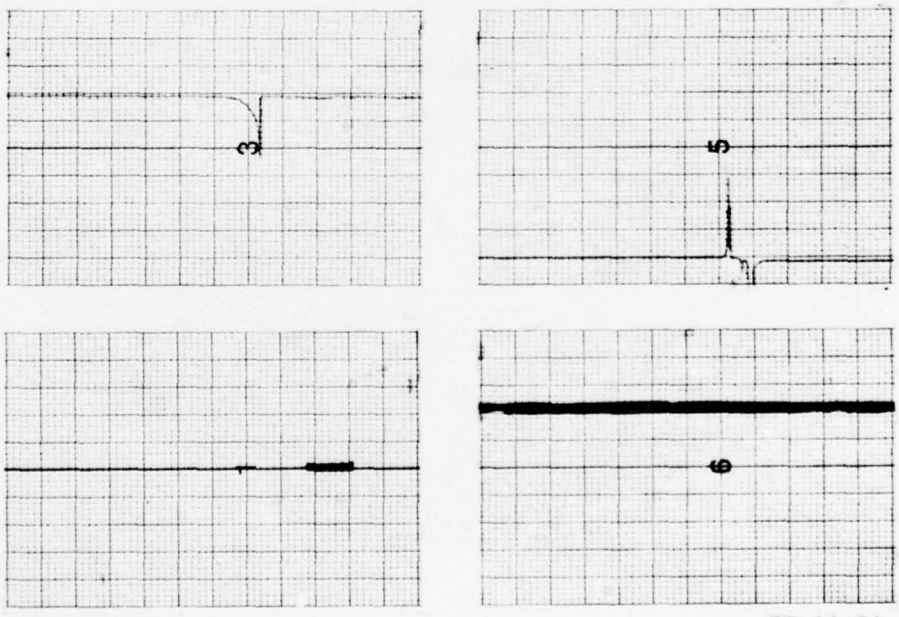
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-24

FIGURE 24. INDIANAPOLIS - WEIR COOK FRAME 1

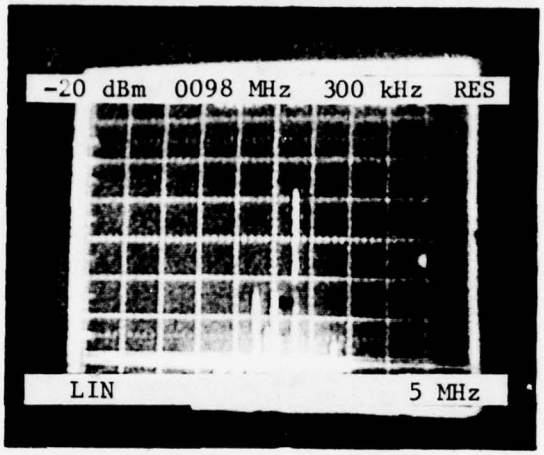
LOCATION - Rwy 4, 7 nmi outbound climbing

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

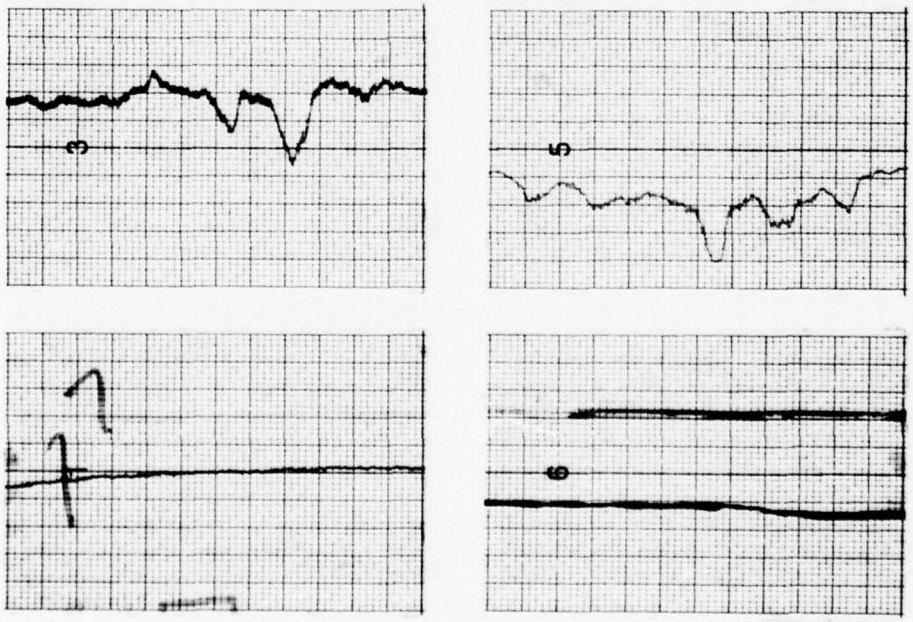
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-25

FIGURE 25. INDIANAPOLIS - WEIR COOK FRAME 2

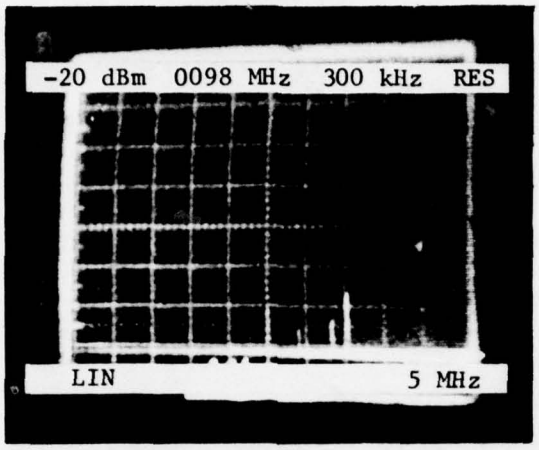
LOCATION - Rwy 4, over outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-26

FIGURE 26. INDIANAPOLIS - WEIR COOK FRAME 3

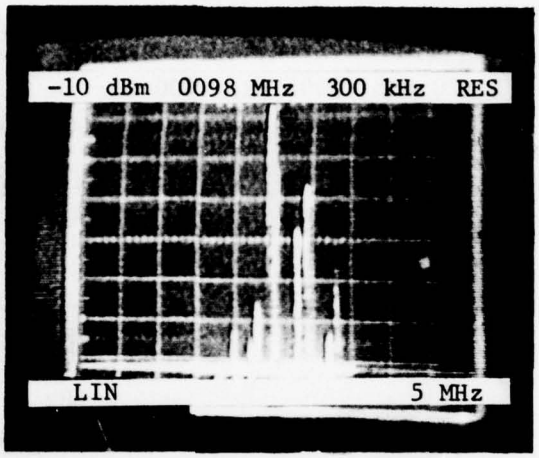
LOCATION - Rwy 4, over outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

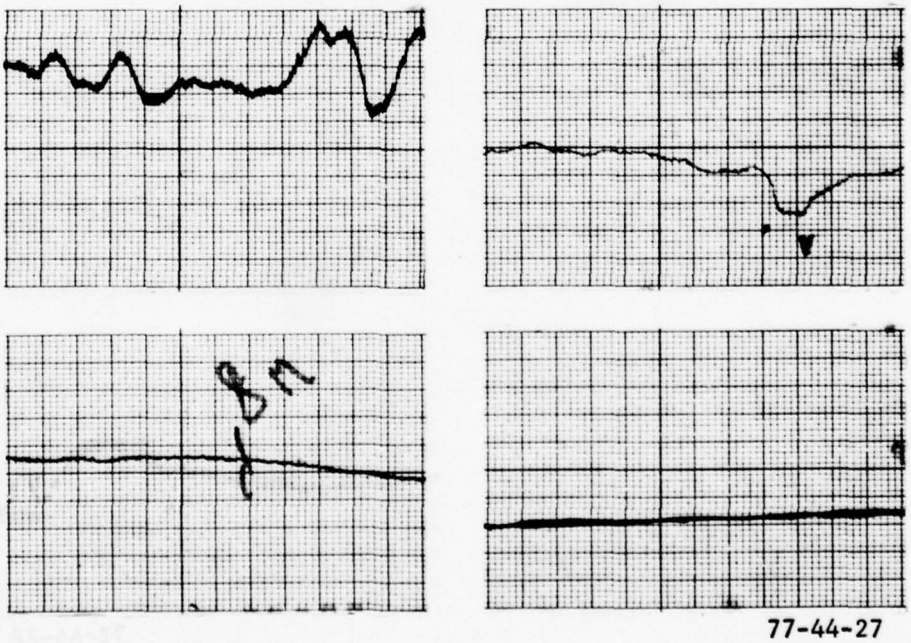
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-27

FIGURE 27. INDIANAPOLIS - WEIR COOK FRAME 4

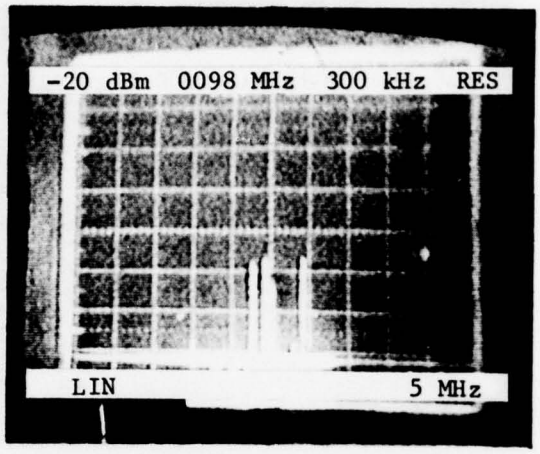
LOCATION - Over airfield

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

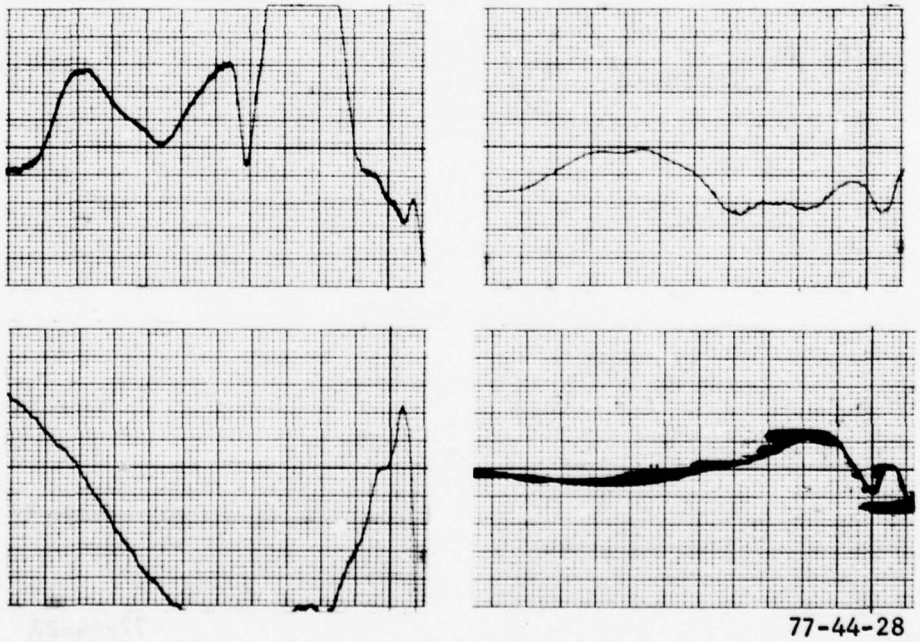
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-28

FIGURE 28. INDIANAPOLIS - WEIR COOK FRAME 5

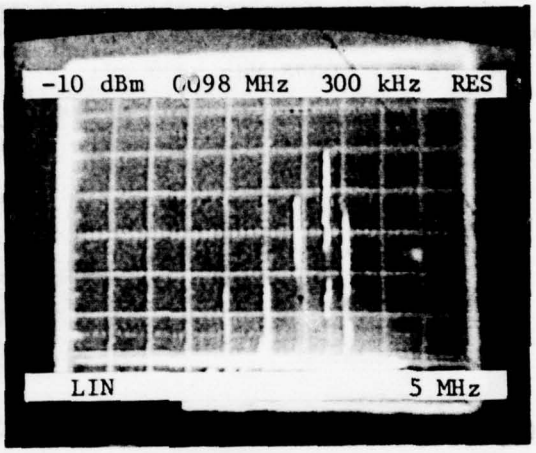
LOCATION - Outbound 10 nmi from airfield

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Heterodyning

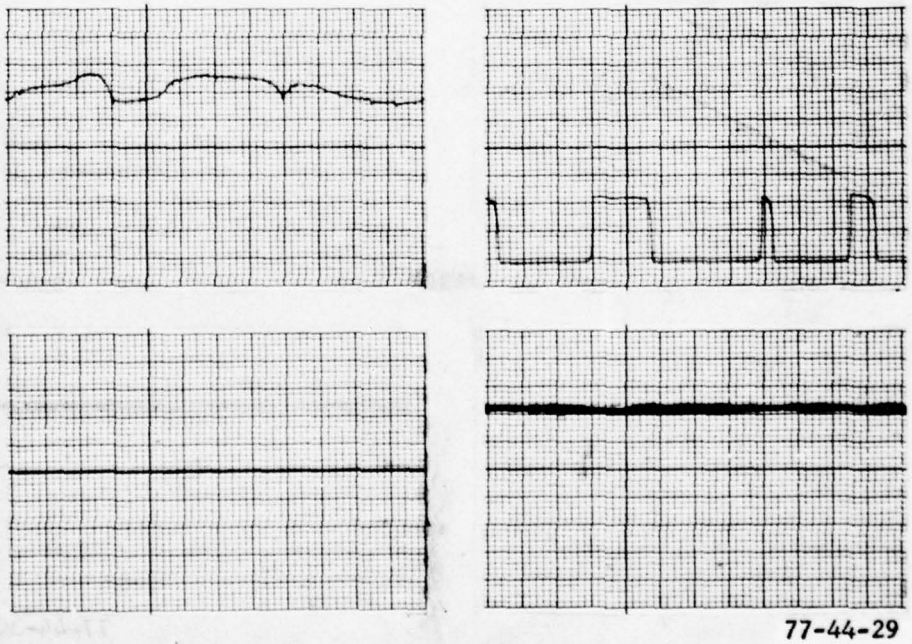
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-29

FIGURE 29. INDIANAPOLIS - WEIR COOK FRAME 6

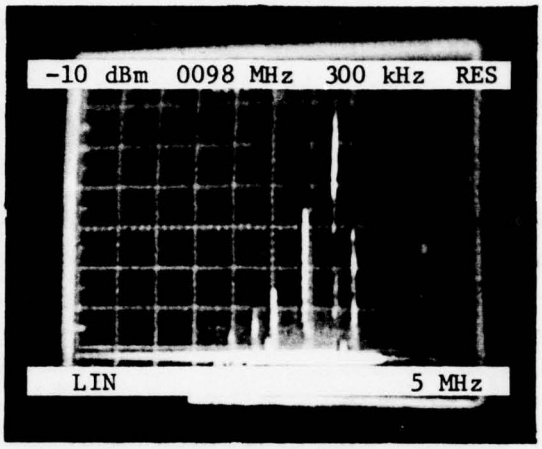
LOCATION - 315°R/17 nmi from SHELBYVILLE (SHB) VORTAC, over ANTENNA #3

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

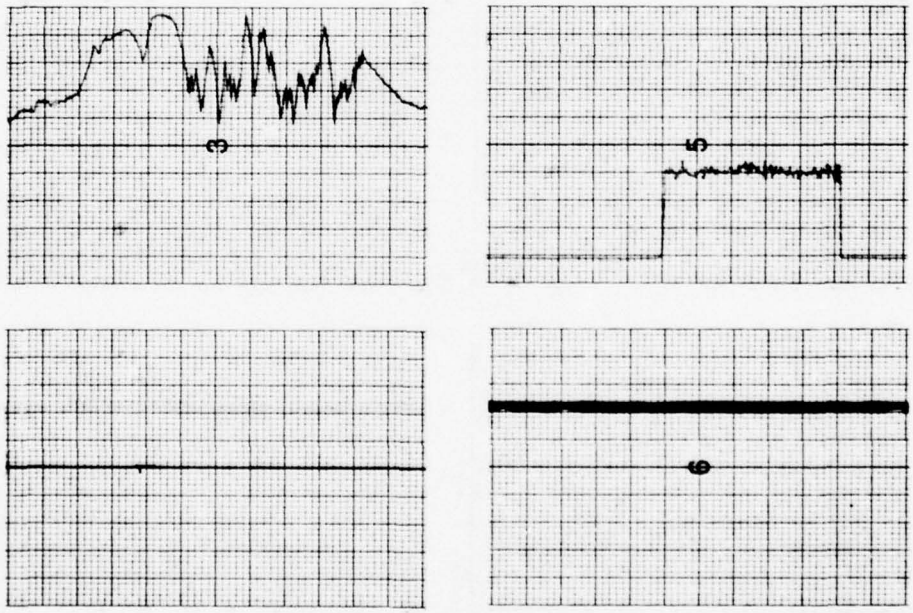
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-30

FIGURE 30. INDIANAPOLIS - WEIR COOK FRAME 7

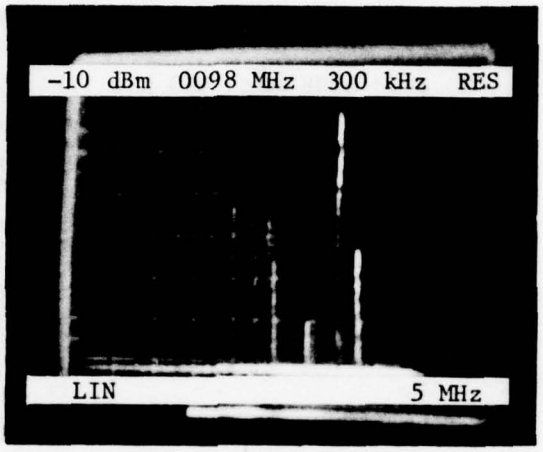
LOCATION - 310°R/20 nmi from SHB VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

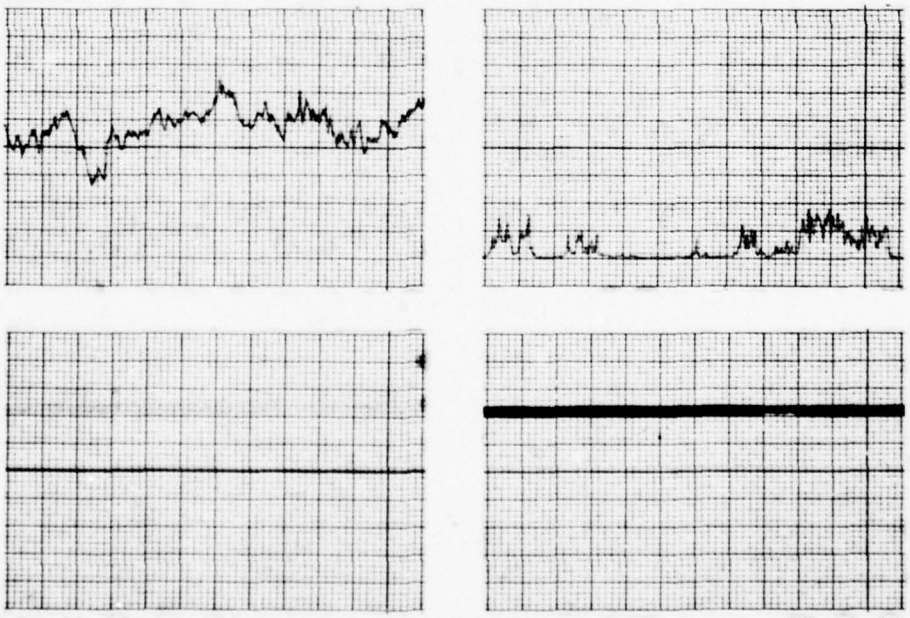
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-31

FIGURE 31. INDIANAPOLIS - WEIR COOK FRAME 8

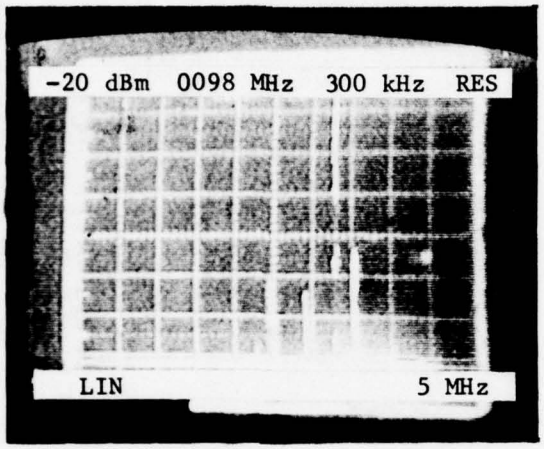
LOCATION - 310°R/23 nmi from SHB VORTAC, over ANTENNA #2

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM



CDI AGC

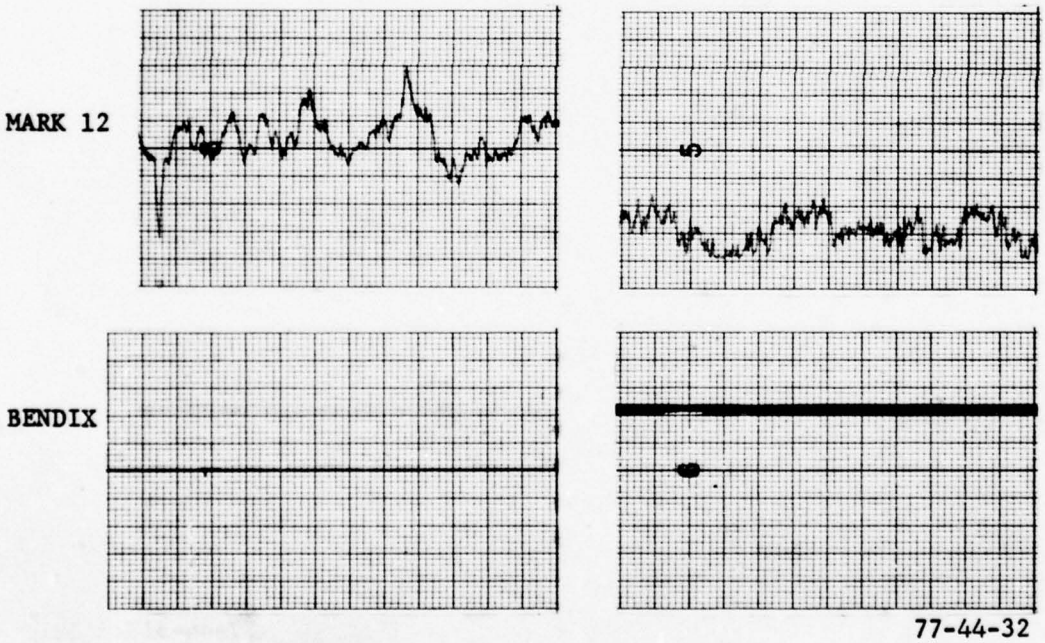


FIGURE 32. INDIANAPOLIS - WEIR COOK FRAME 9

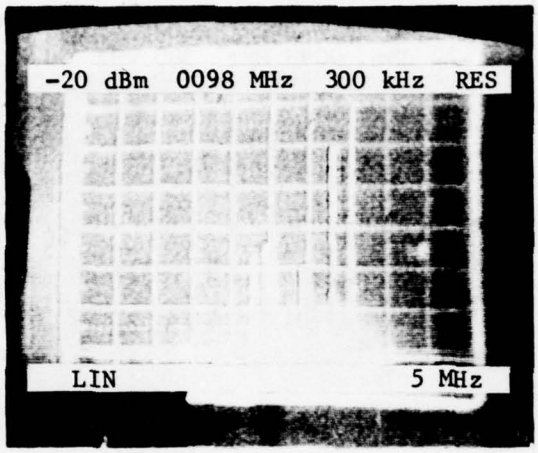
LOCATION- 130°R/17 nmi from SHB VORTAC over ANTENNA #3

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

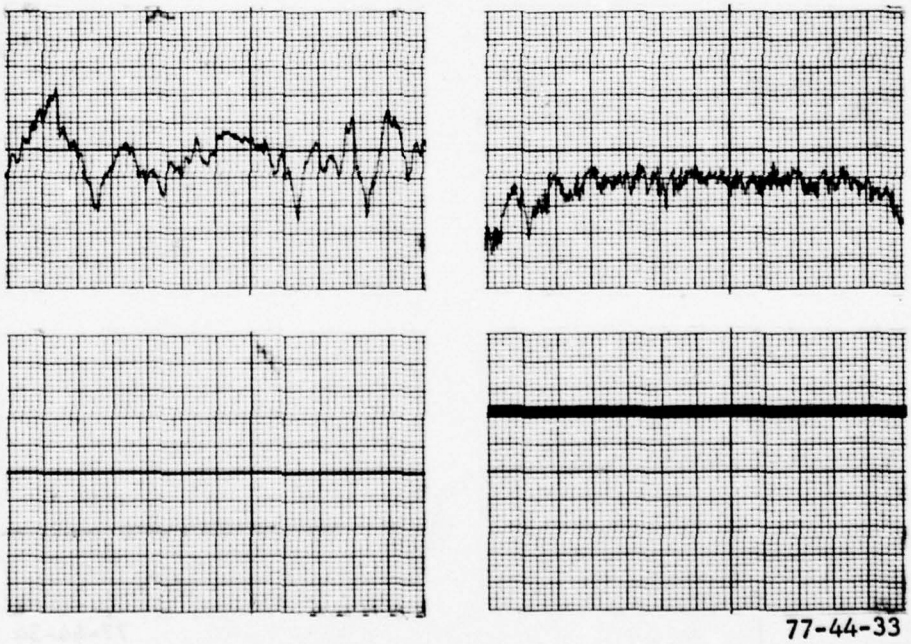
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-33

FIGURE 33. INDIANAPOLIS - WEIR COOK FRAME 10

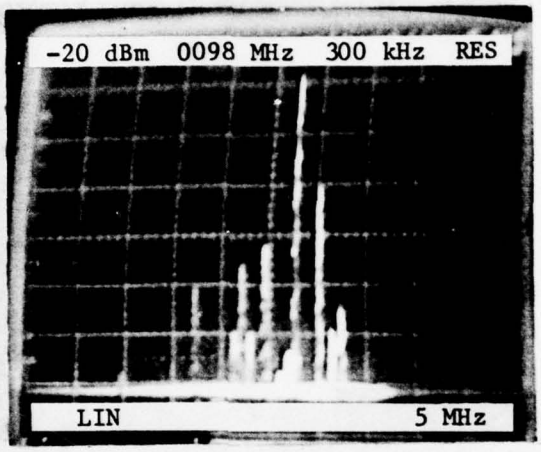
LOCATION - Between middle and outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12- Aircraft Engine Noise

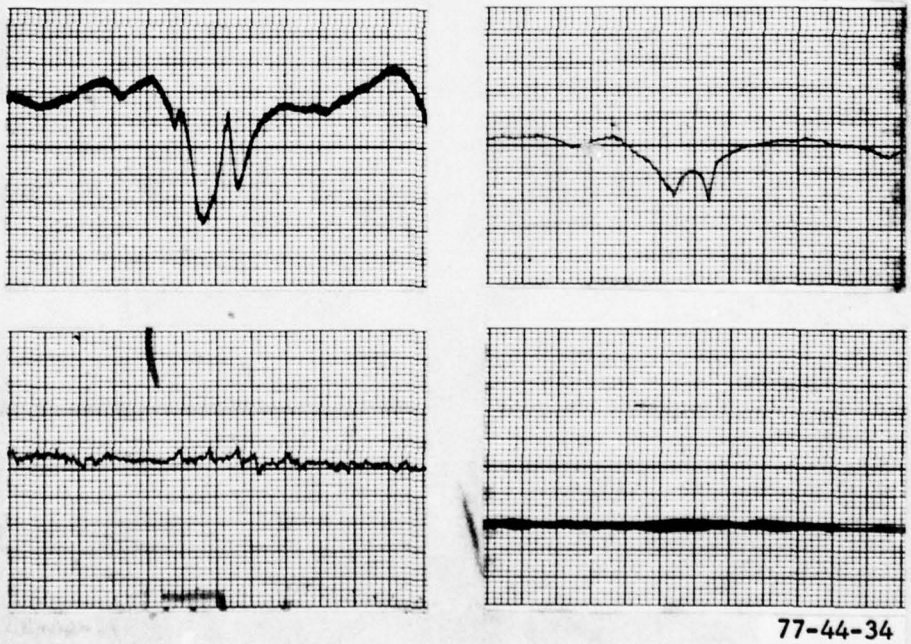
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-34

FIGURE 34. KANSAS CITY - FAIRFAX FRAME 1

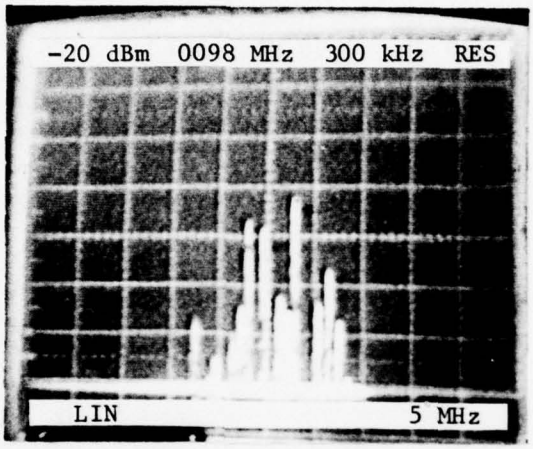
LOCATION - 3 to 5 nmi from threshold

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Aircraft Engine Noise

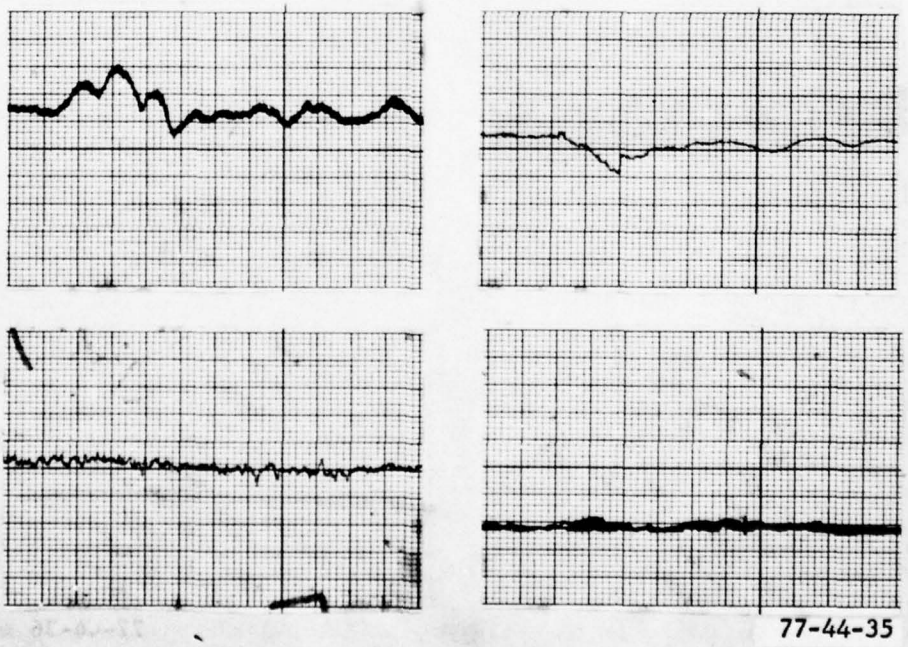
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-35

FIGURE 35. KANSAS CITY - FAIRFAX FRAME 2

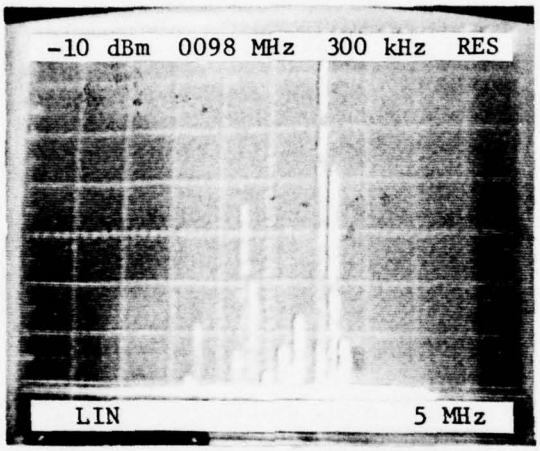
LOCATION - 031°R/11 nmi from KANSAS CITY VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-36

FIGURE 36. KANSAS CITY - FAIRFAX FRAME 3

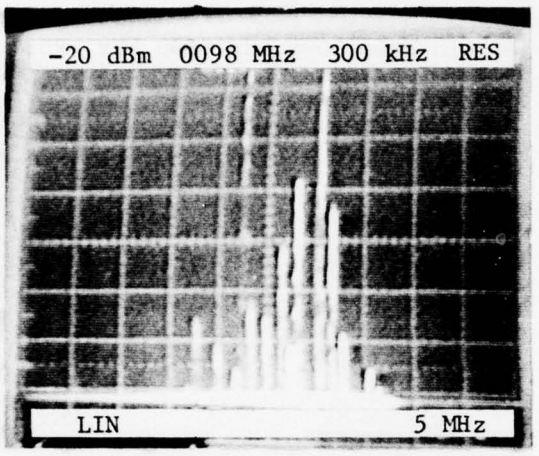
LOCATION - 031°R/14 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

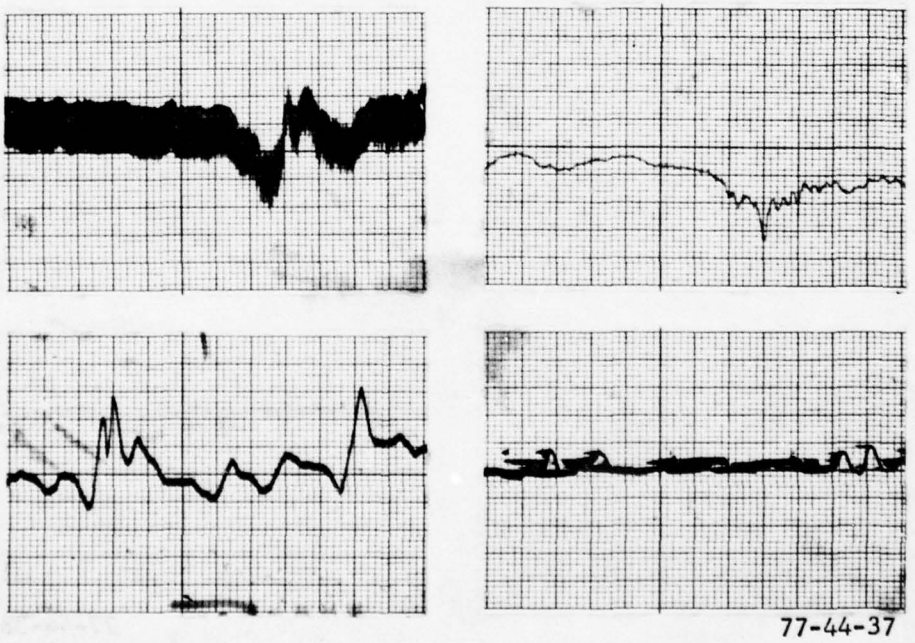
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-37

FIGURE 37. KANSAS CITY - FAIRFAX FRAME 4

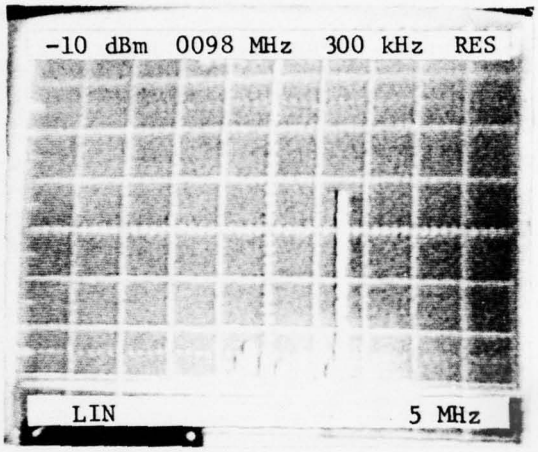
LOCATION - 320°R/13 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-38

FIGURE 38. KANSAS CITY - FAIRFAX FRAME 5

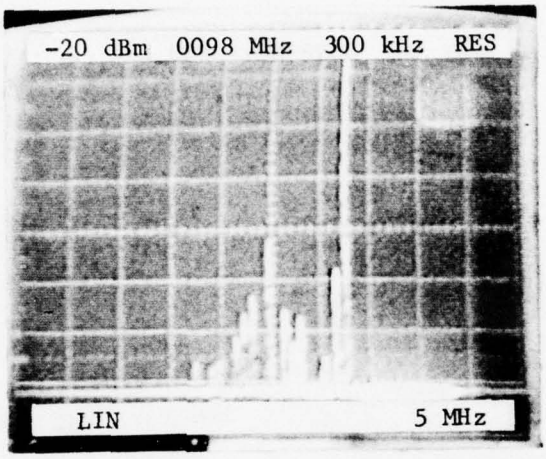
LOCATION - 308°R/13 nmi from VORTAC over ANTENNA #4

AUDIO INTERFERENCES

BENDIX- None

MARK 12-None

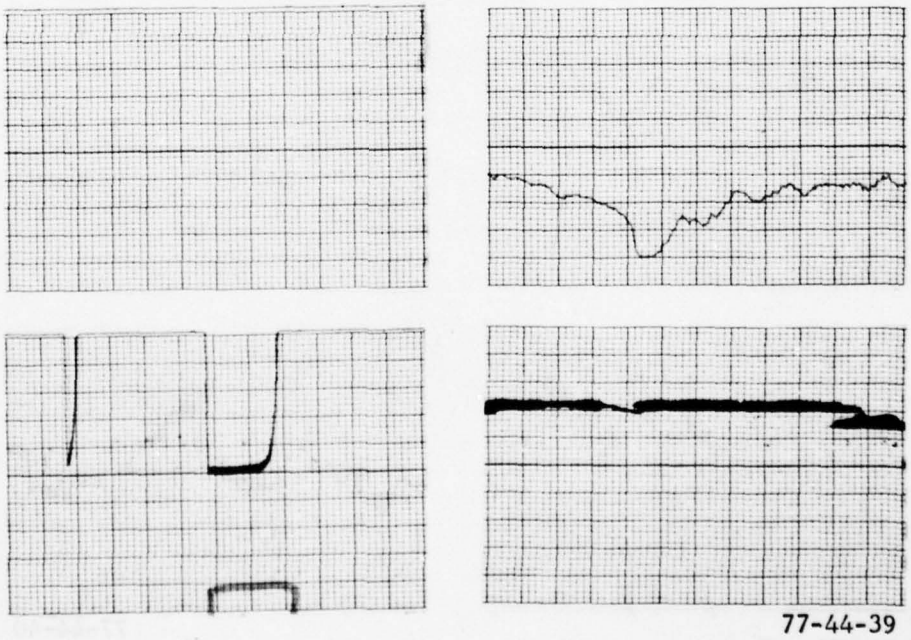
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-39

FIGURE 39. KANSAS CITY - FAIRFAX FRAME 6

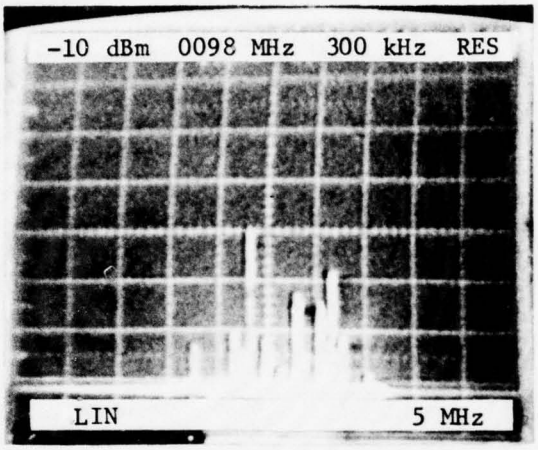
LOCATION - 360°R/13 nmi from VORTAC, over ANTENNA #6

AUDIO INTERFERENCES

BENDIX-None

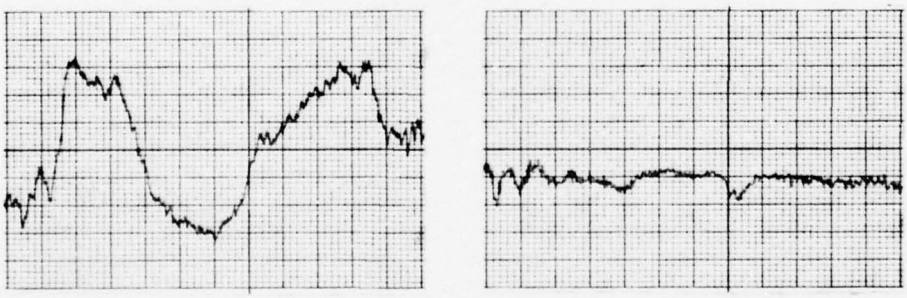
MARK 12- Music and Speech

FM SPECTRUM

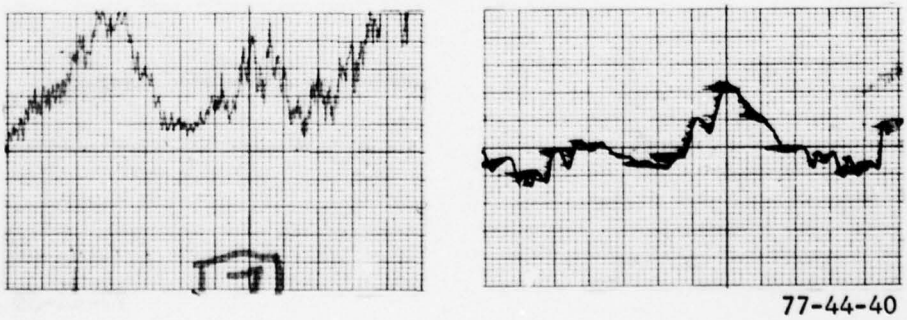


CDI AGC

MARK 12



BENDIX



77-44-40

FIGURE 40. KANSAS CITY - FAIRFAX FRAME 7

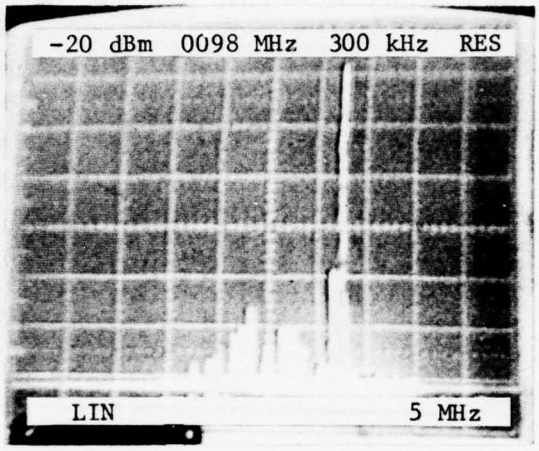
LOCATION - 300°R/13 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX- High Background Noise

MARK 12- Motorboating Sound

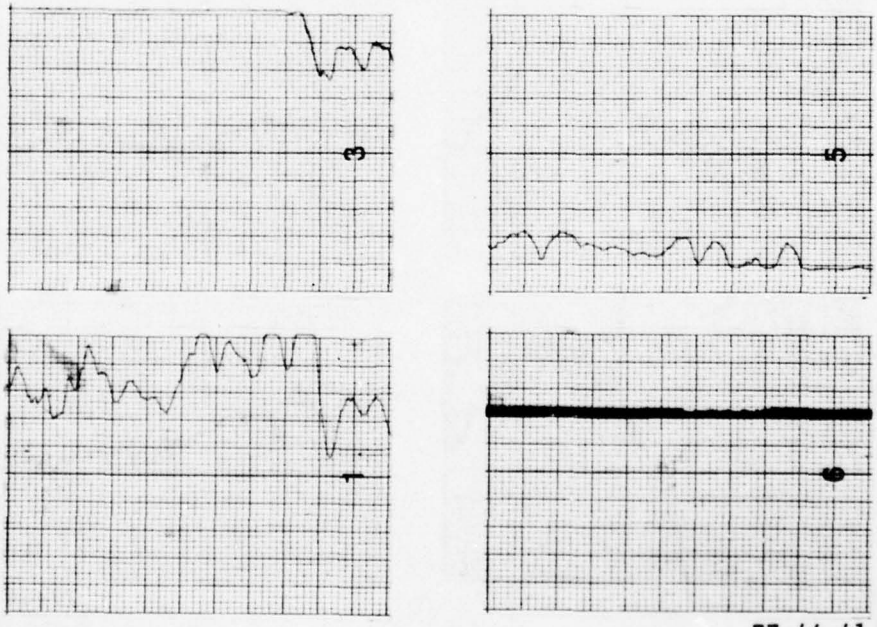
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-41

FIGURE 41. KANSAS CITY - FAIRFAX FRAME 8

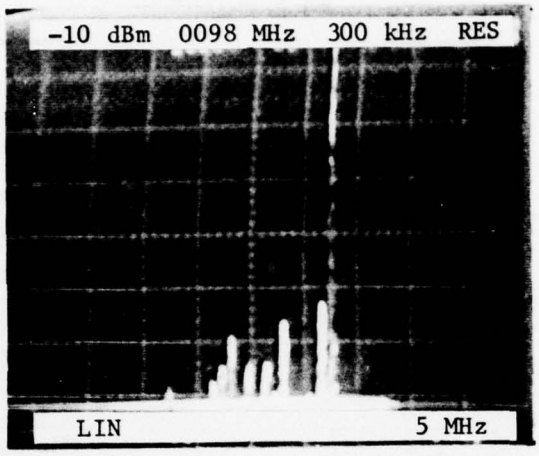
LOCATION - 360°R/13 nmi from VORTAC, over ANTENNA #6

AUDIO INTERFERENCES

BENDIX-Motorboating sound

MARK 12- Music

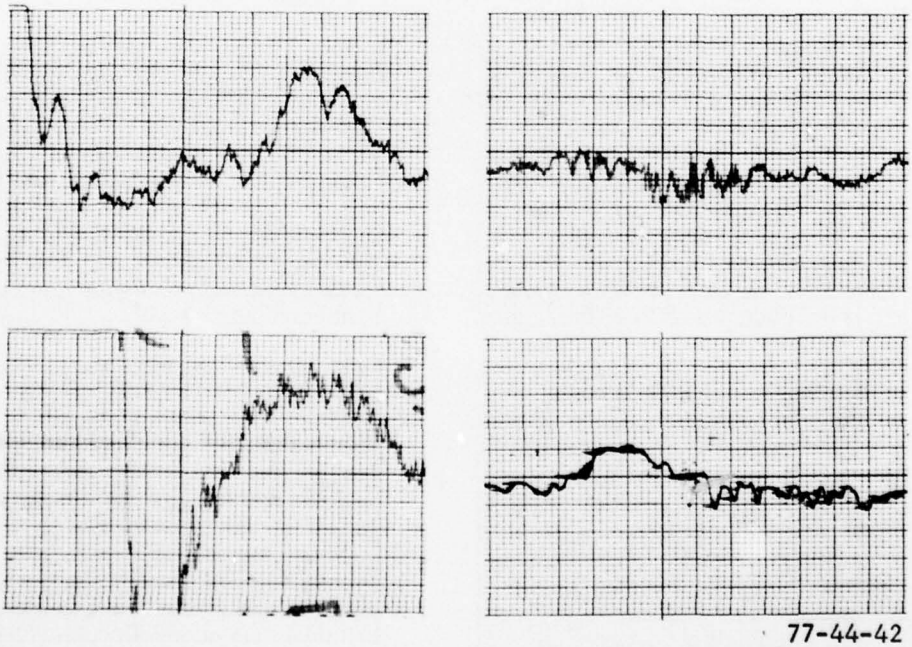
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-42

FIGURE 42. KANSAS CITY - FAIRFAX FRAME 9

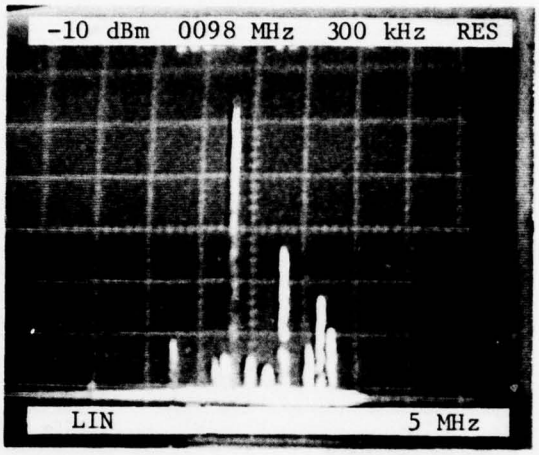
LOCATION - 315°R/13 nmi VORTAC, between ANTENNA #8 and #4

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

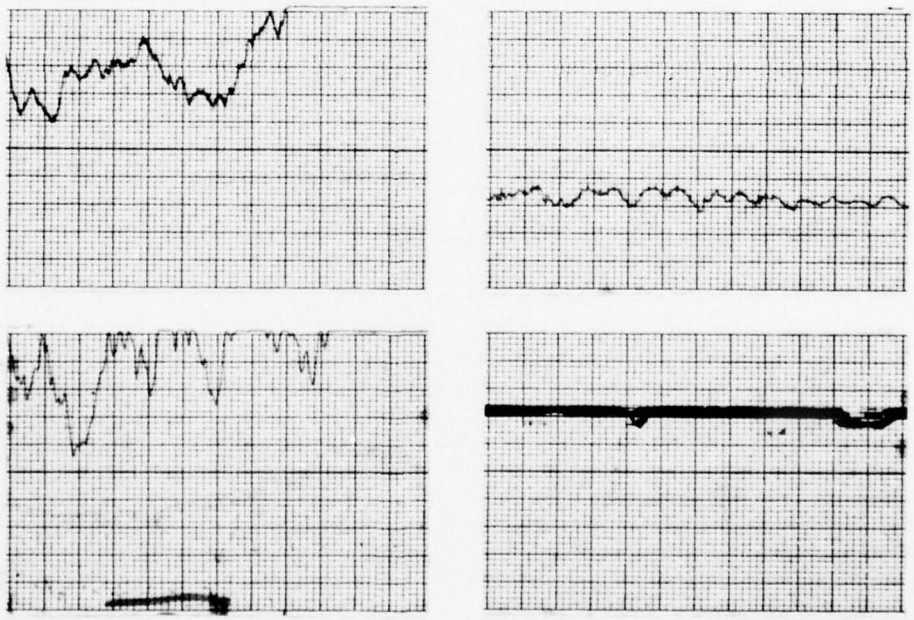
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-43

FIGURE 43. KANSAS CITY - FAIRFAX FRAME 10

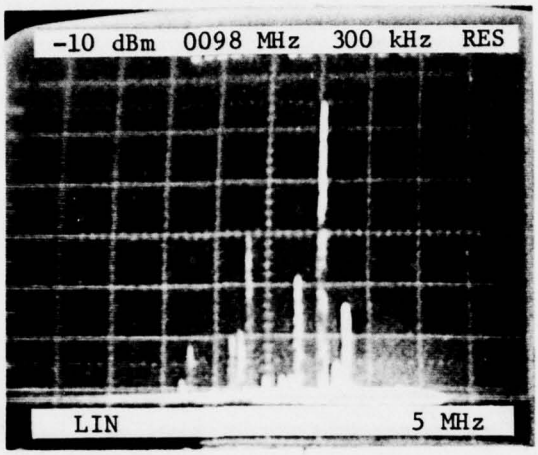
LOCATION - 355°R, over ANTENNA #6

AUDIO INTERFERENCES

BENDIX- Motorboating Sound

MARK 12- Motorboating Sound

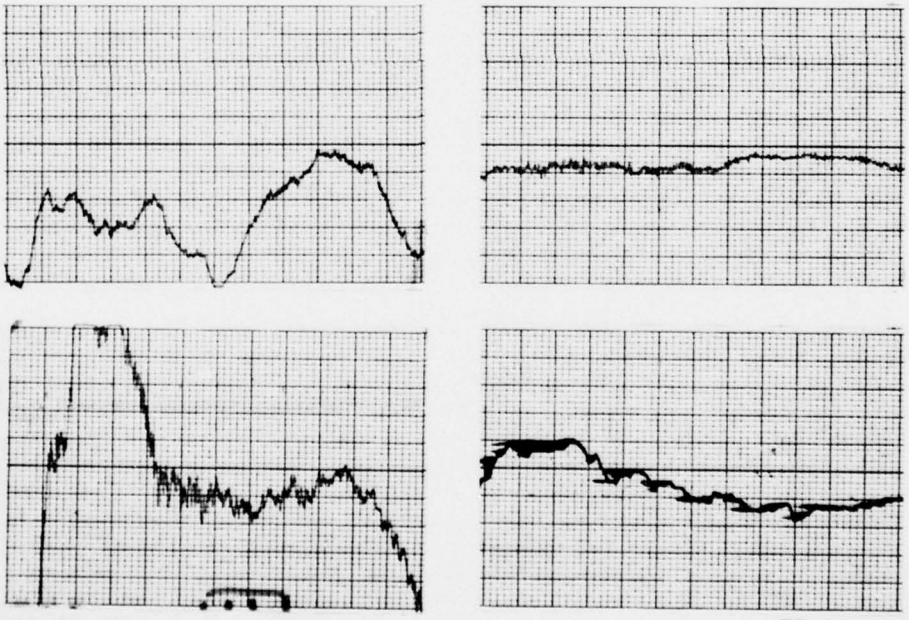
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-44

FIGURE 44. KANSAS CITY - FAIRFAX FRAME 11

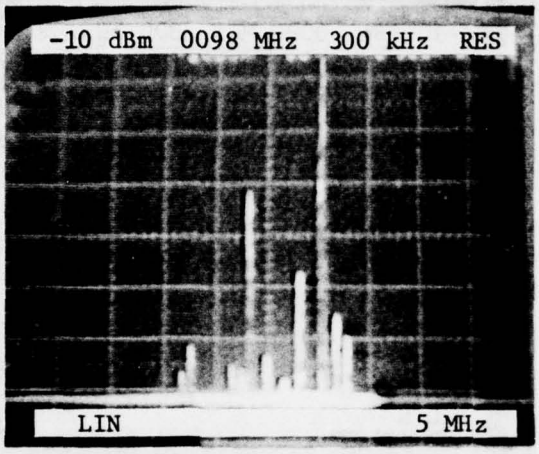
LOCATION - 116°R/1 nmi outbound

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Aircraft Engine Noise

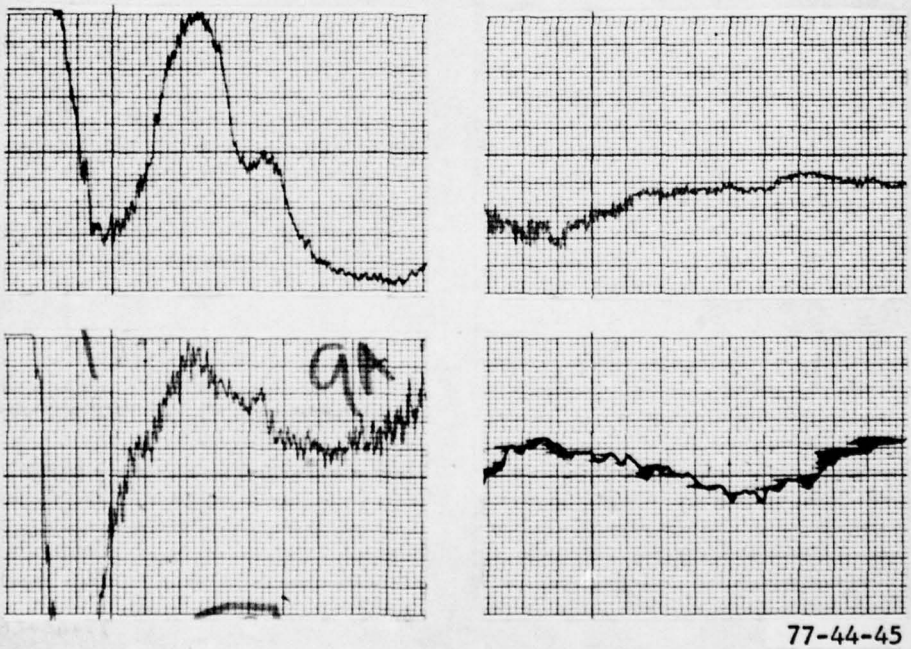
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-45

FIGURE 45. KANSAS CITY - FAIRFAX FRAME 12

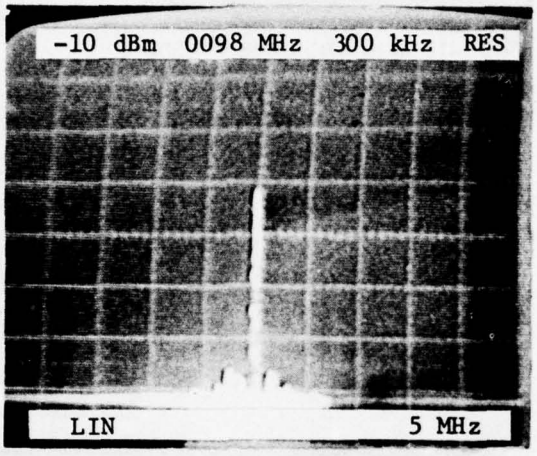
LOCATION - 310°R, over ANTENNA #4

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

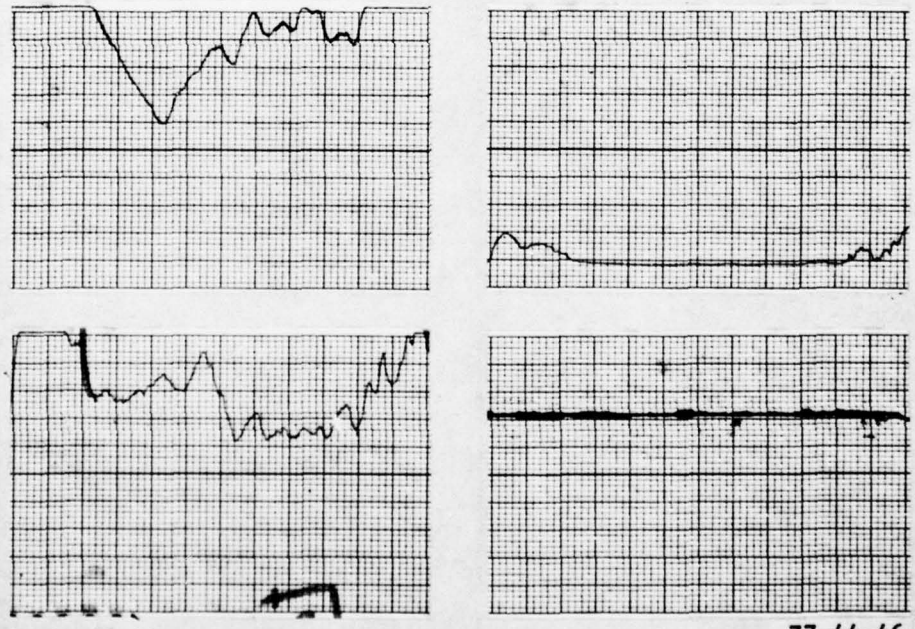
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-46

FIGURE 46. KANSAS CITY - FAIRFAX FRAME 13

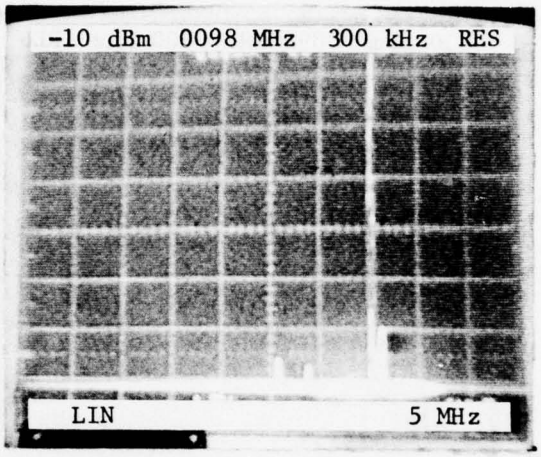
LOCATION - Rwy 13, 9 nmi from threshold

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

FIGURE 47. TOPEKA - PHILIP BILLARD FRAME 1

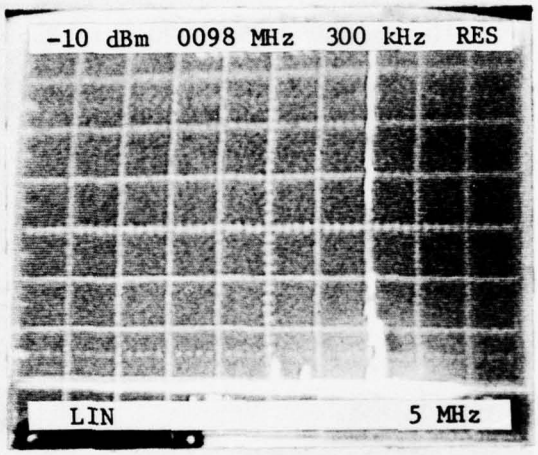
LOCATION - Rwy 13, 7 nmi from threshold

AUDIO INTERFERENCES

BENDIX- None

MARK 12- None

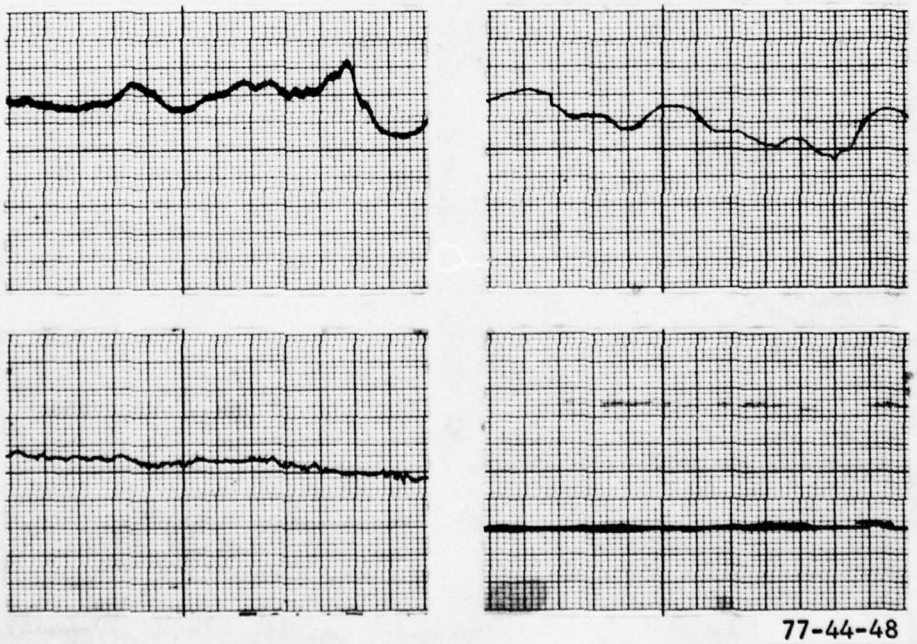
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-48

FIGURE 48. TOPEKA - PHILIP BILLARD FRAME 2

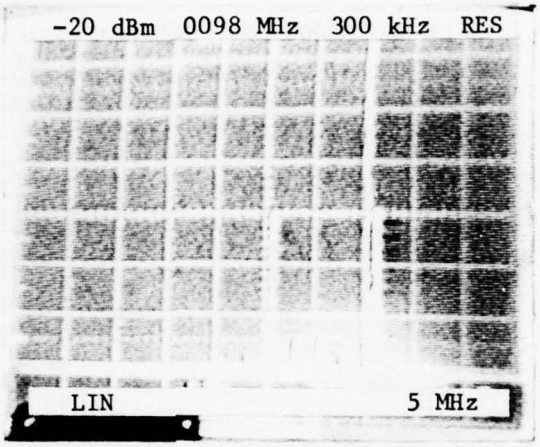
LOCATION - Rwy 13, 3 nmi from outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

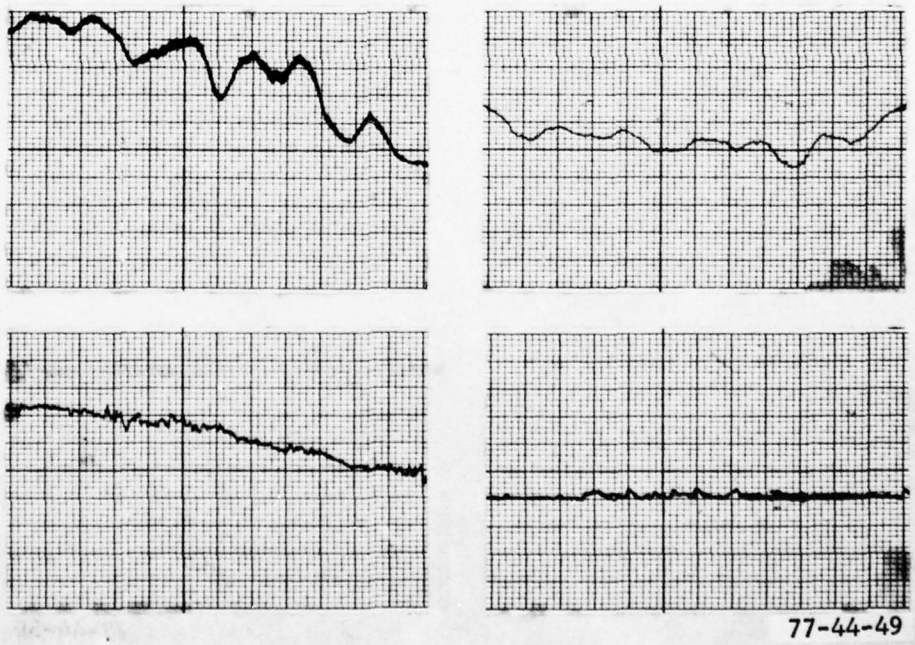


FIGURE 49. TOPEKA - PHILIP BILLARD FRAME 3

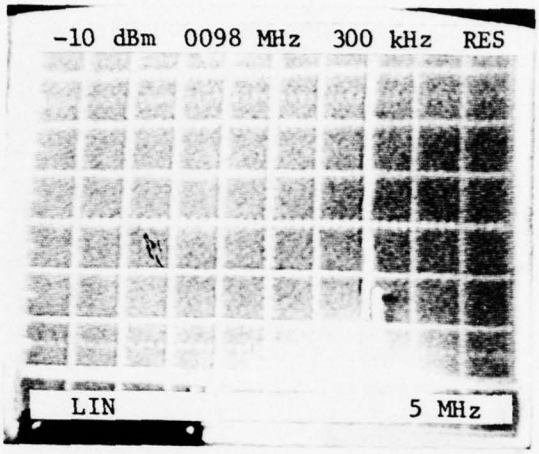
LOCATION - Rwy 8, 4 nmi from threshold

AUDIO INTERFERENCES

BENDIX-None

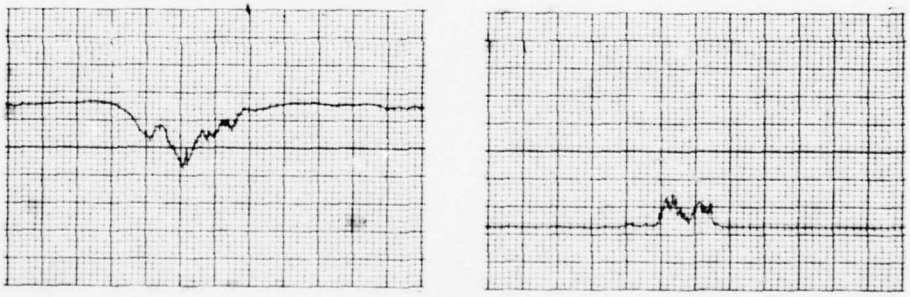
MARK 12-Music

FM SPECTRUM

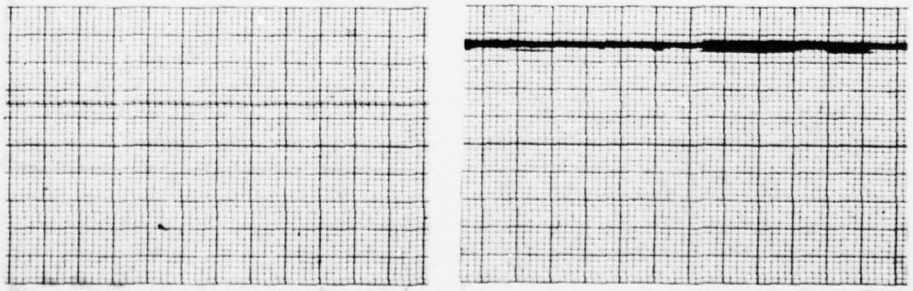


CDI AGC

MARK 12



BENDIX



77-44-50

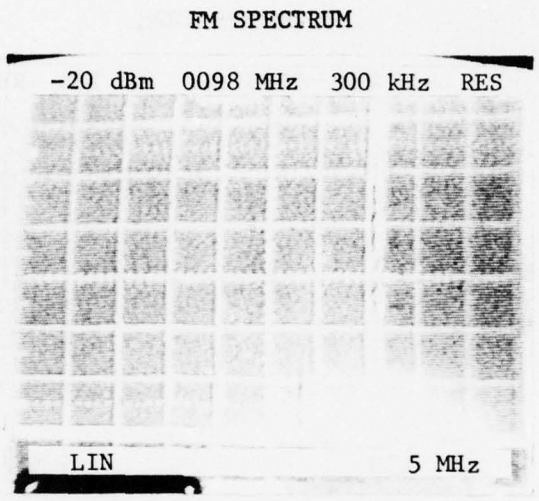
FIGURE 50. TOPEKA - PHILIP BILLARD FRAME 4

LOCATION - 4 nmi from threshold

AUDIO INTERFERENCES

BENDIX- None

MARK 12-Music and speech



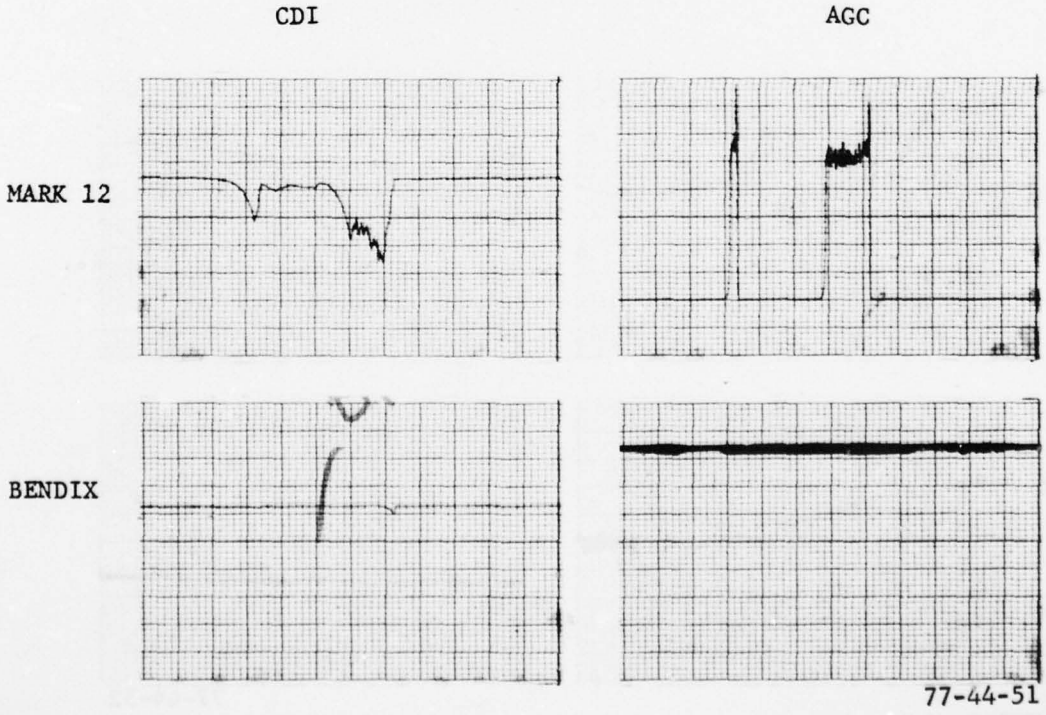


FIGURE 51. TOPEKA - PHILIP BILLARD FRAME 5

AD-A058 903 NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER ATL--ETC F/G 20/14
INTERFERENCE IN COMMUNICATIONS AND NAVIGATION AVIONICS FROM COM--ETC(U)
JUN 78 E M SAWTELLE, J G DONG

UNCLASSIFIED FAA-NA-77-44 FAA-RD-78-35 NL

2 OF 3
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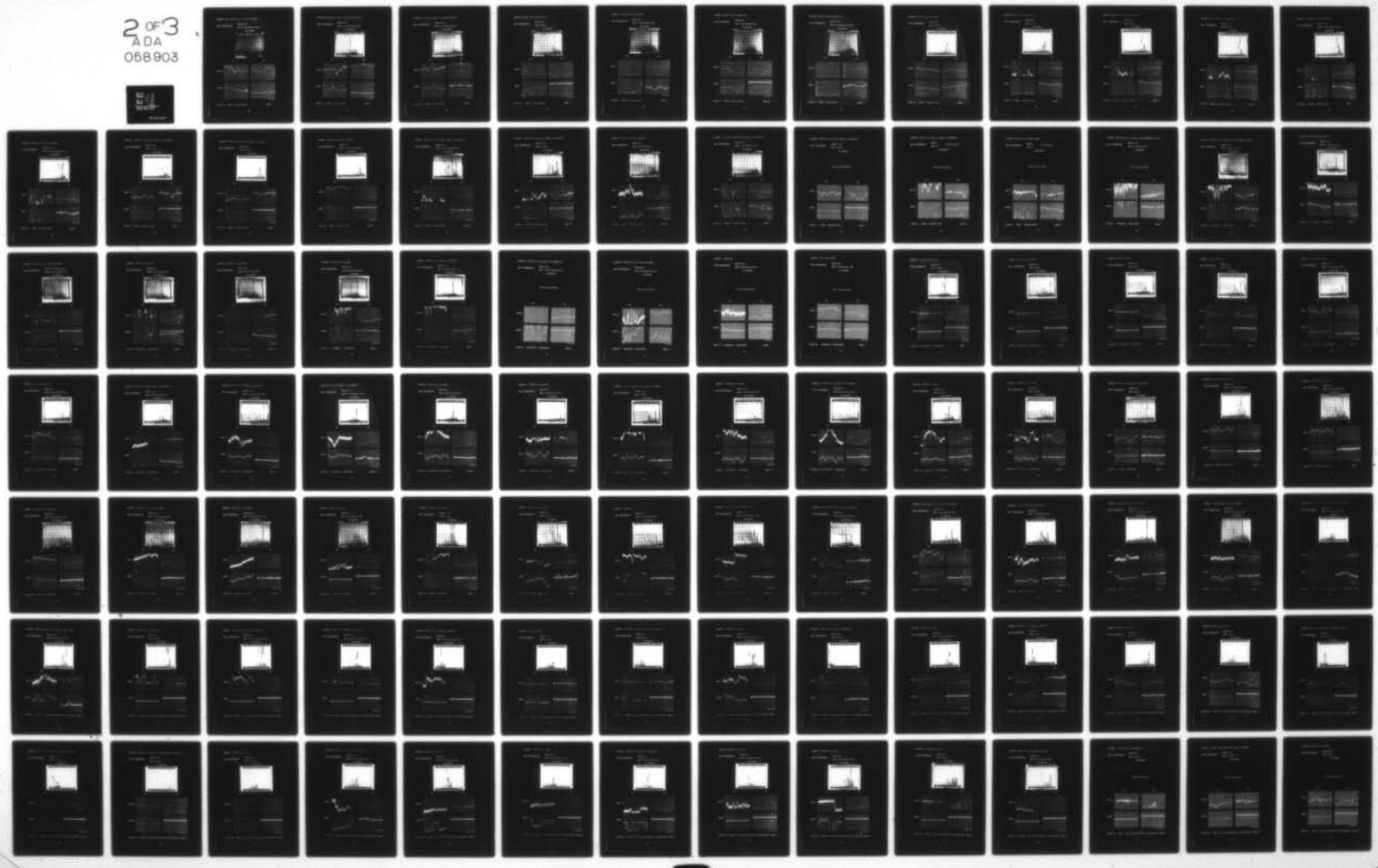
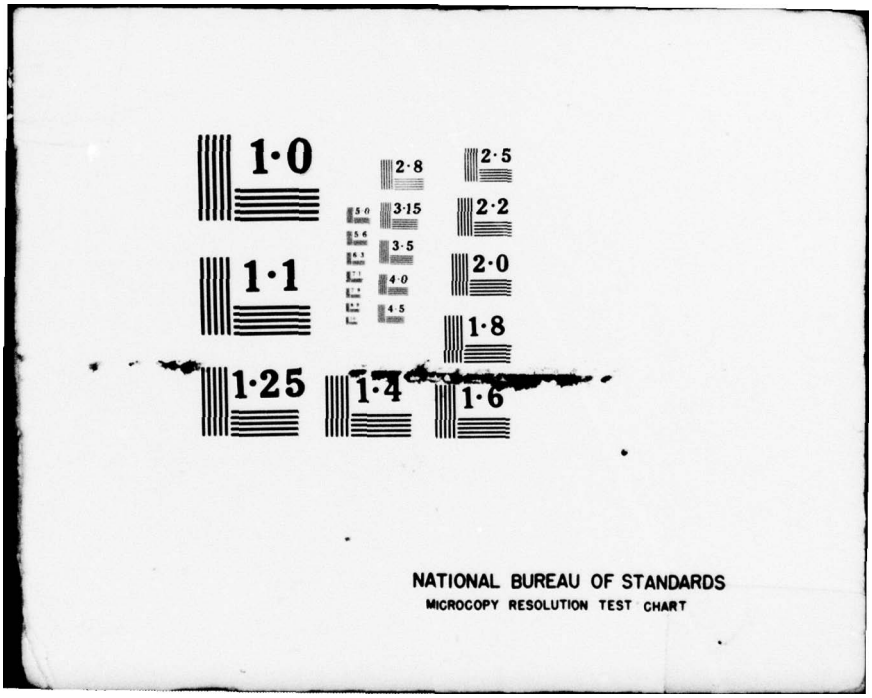



1·0
1·1
1·25
1·4
1·6
1·8
2·0
2·2
2·5
2·8
3·15
3·5
4·0
4·5
5·0
NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

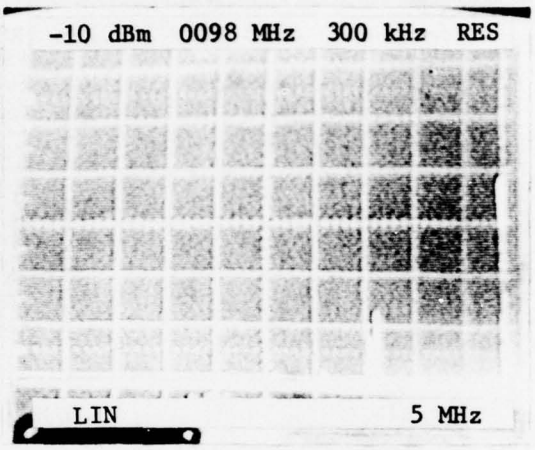
LOCATION - Back course, Rwy 31, 4 nmi to threshold

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

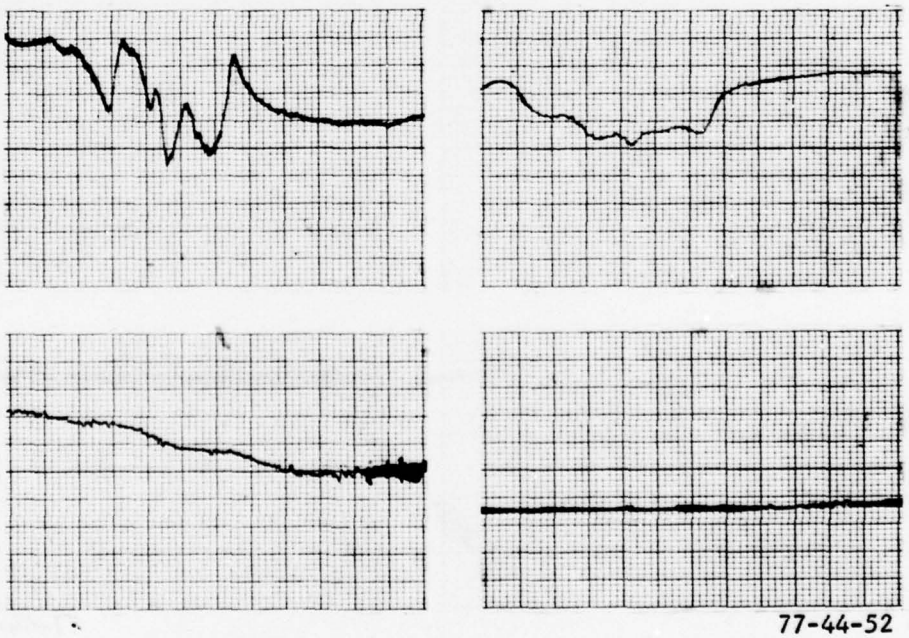
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-52

FIGURE 52. TOPEKA - PHILIP BILLARD FRAME 6

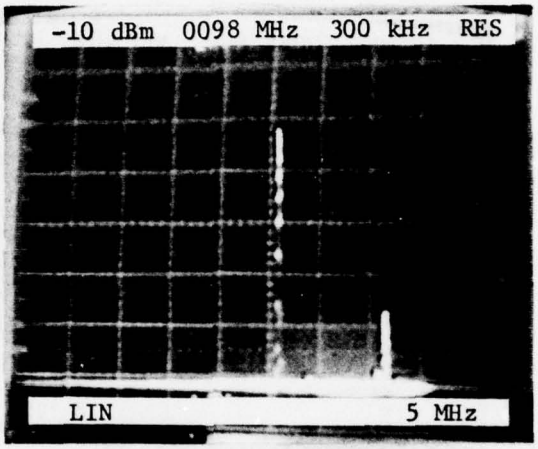
LOCATION - Back Course, Rwy 31, 1/2 nmi from localizer

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

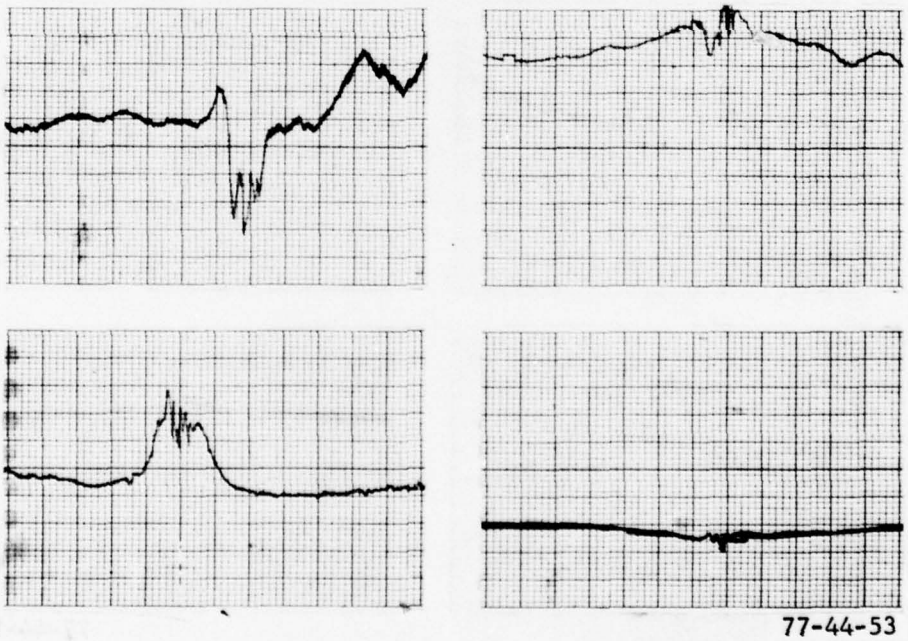
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-53

FIGURE 53. TOPEKA - PHILIP BILLARD FRAME 7

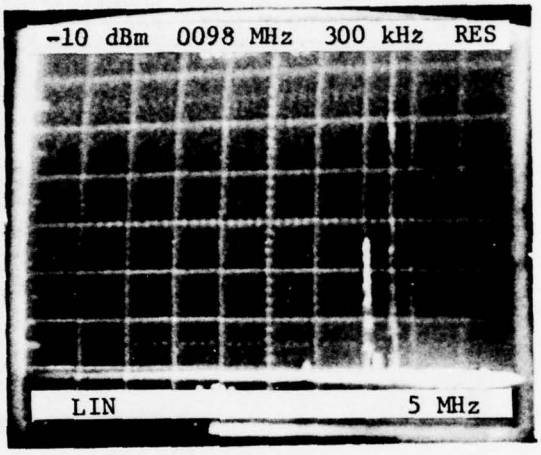
LOCATION - Back course, Rwy 31, ½ nmi from threshold

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

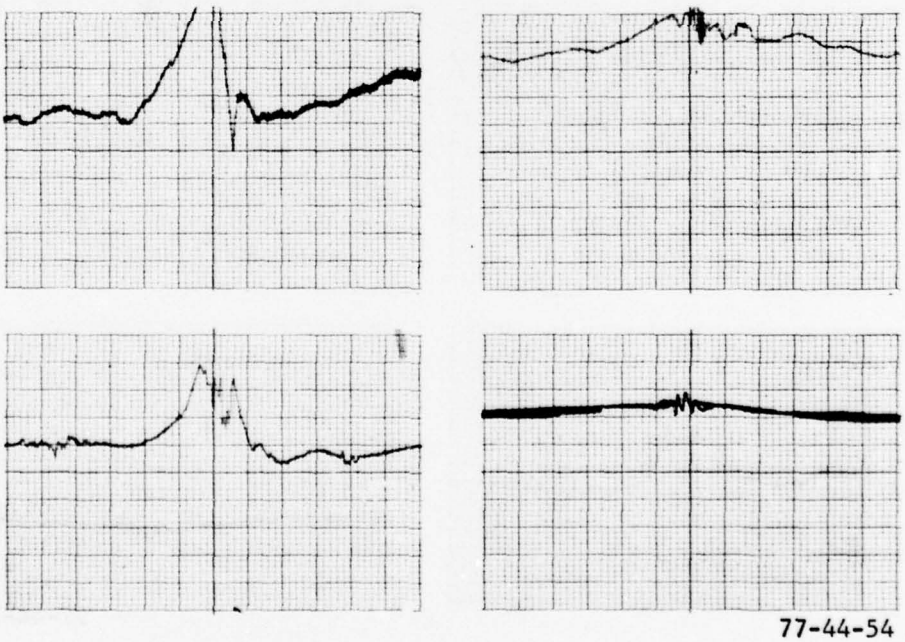
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-54

FIGURE 54. TOPEKA - PHILIP BILLARD FRAME 8

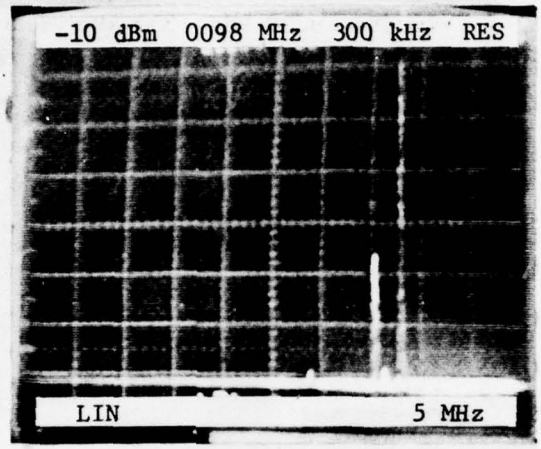
LOCATION - 250°R/24 nmi from Topeka VOR

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

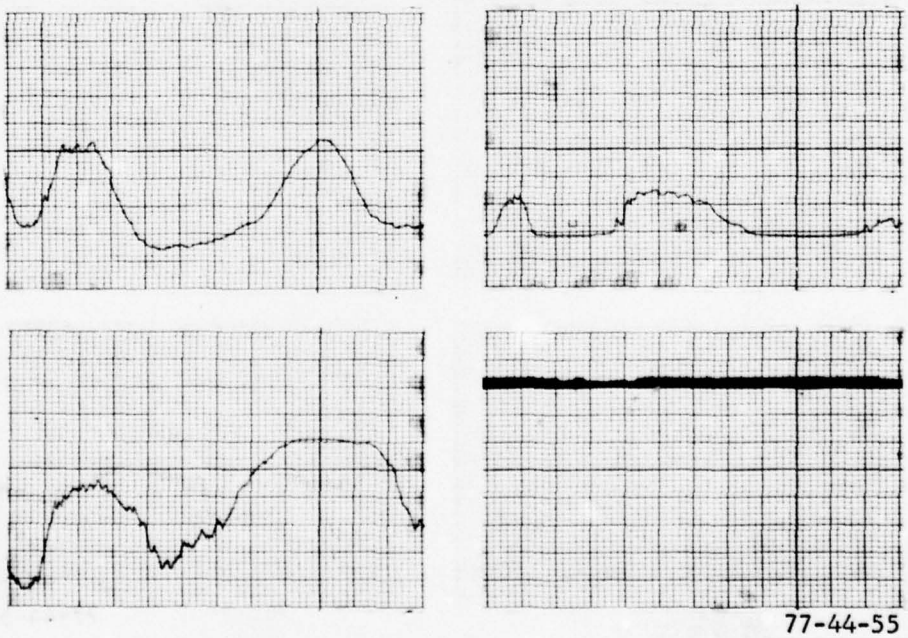


FIGURE 55. TOPEKA - PHILIP BILLARD FRAME 9

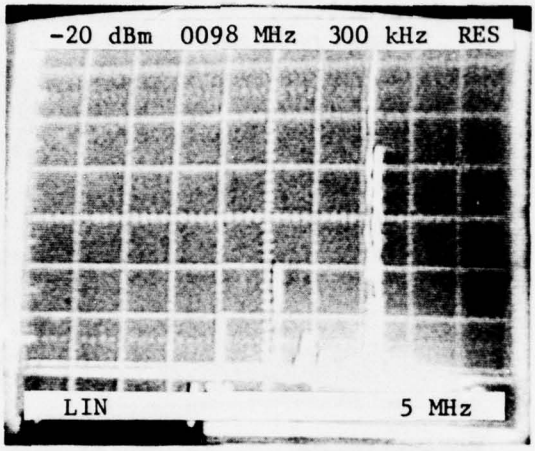
LOCATION - 240°R/14 nmi from Topeka VOR

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

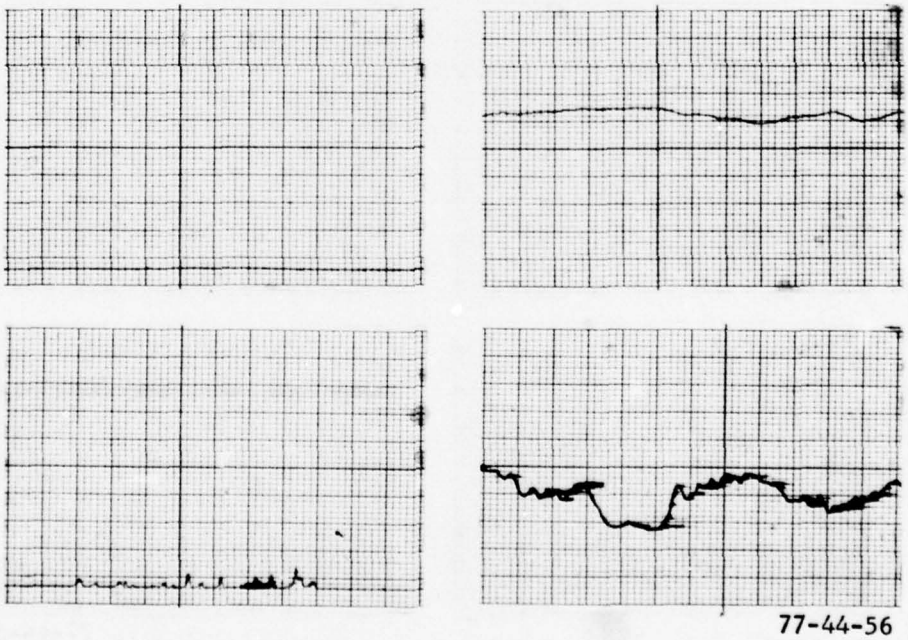
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-56

FIGURE 56. TOPEKA - PHILIP BILLARD FRAME 10

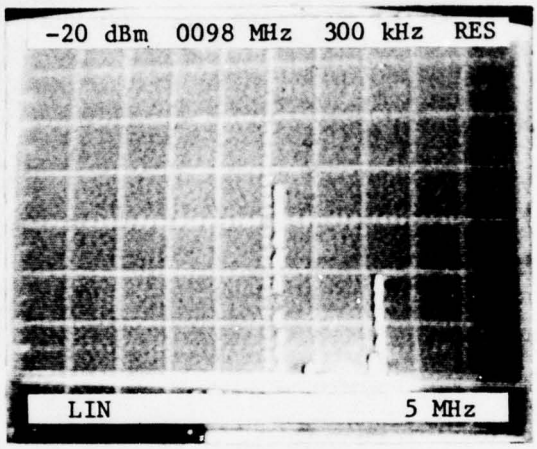
LOCATION - 240°R/26 nmi from Topeka VOR

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

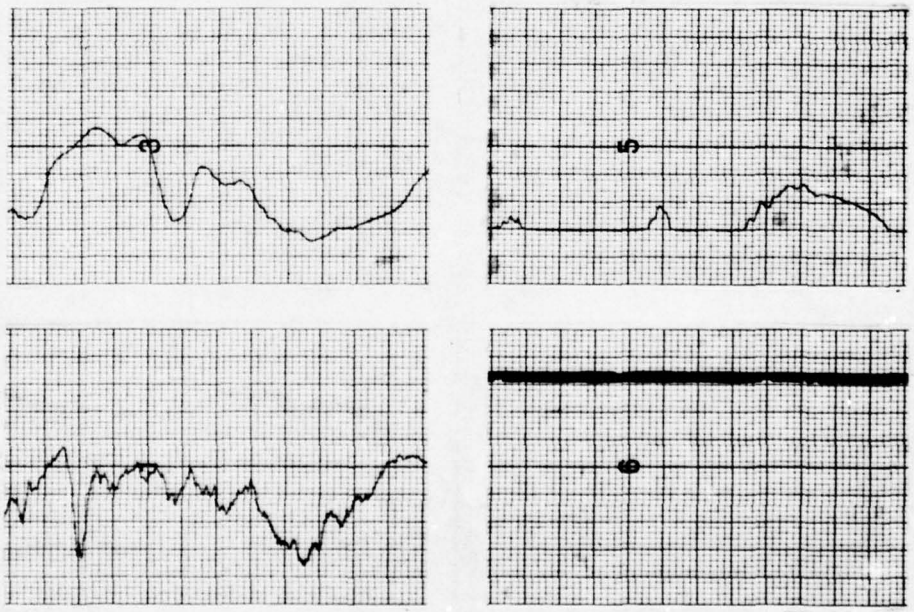
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-57

FIGURE 57. TOPEKA - PHILIP BILLARD FRAME 11

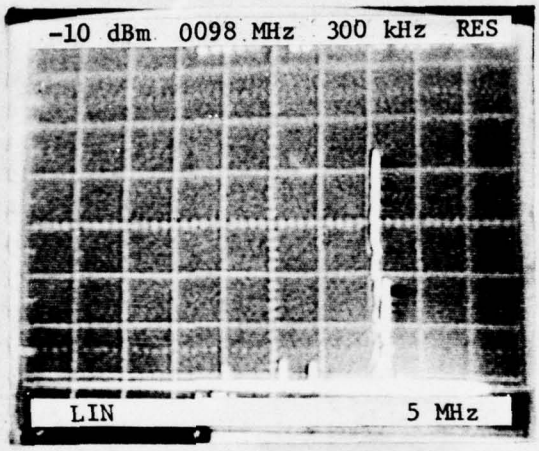
LOCATION - 260°R/10 nmi from Topeka VOR

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-58

FIGURE 58. TOPEKA - PHILIP BILLARD FRAME 12

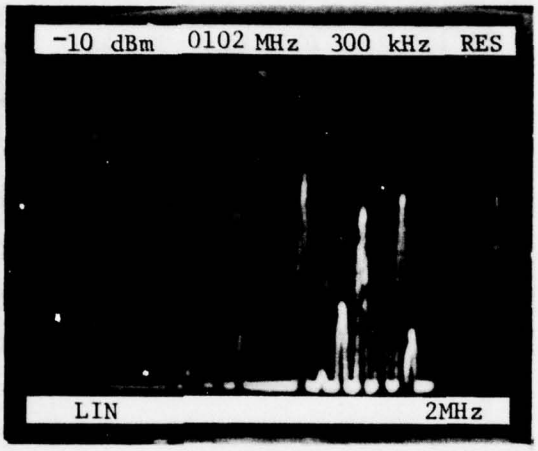
LOCATION - Rwy 29R, over outer marker

AUDIO INTERFERENCES

BENDIX-None

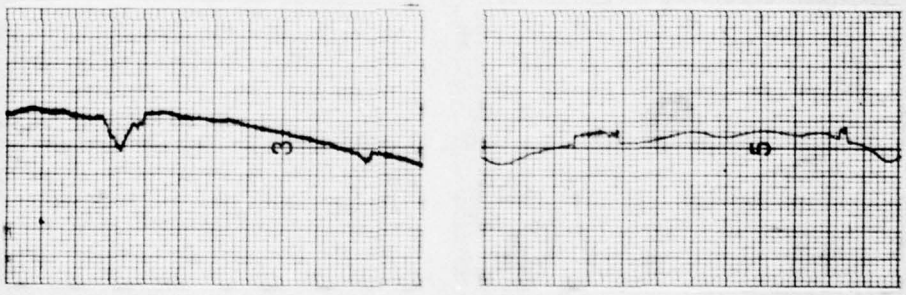
MARK 12-Music

FM SPECTRUM



CDI AGC

MARK 12



BENDIX

77-44-59

FIGURE 59. DENVER - JEFFERSON COUNTY FRAME 1

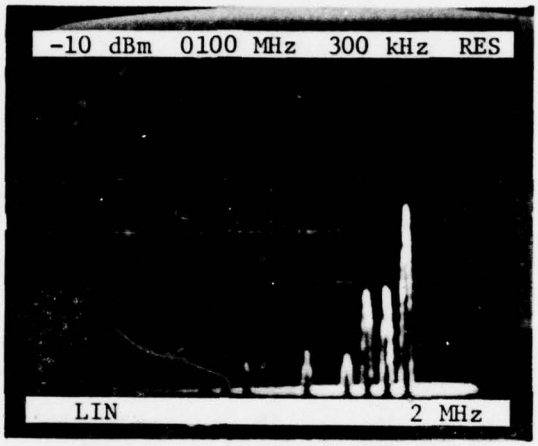
LOCATION - Rwy 29R, over outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

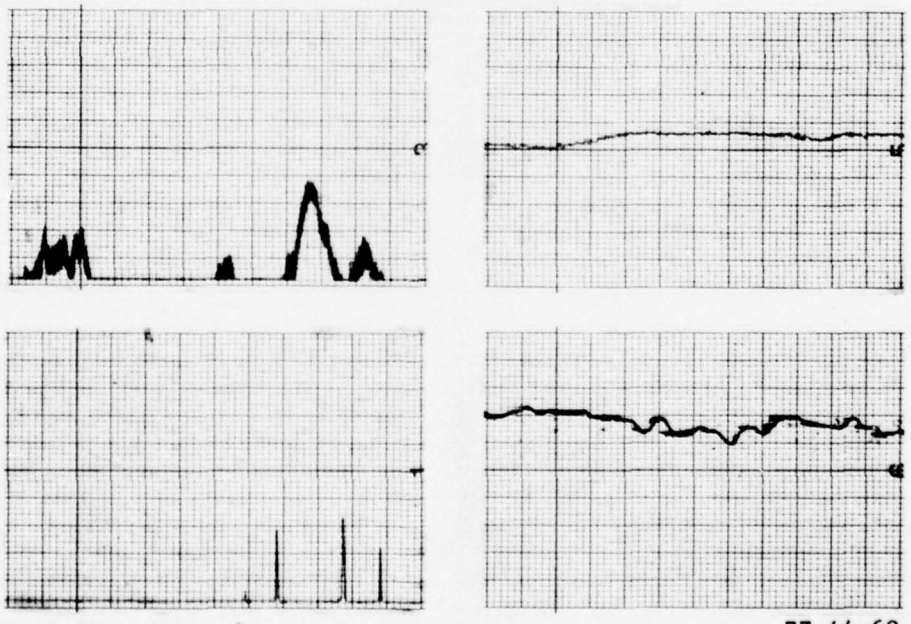
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-60

FIGURE 60. DENVER - JEFFERSON COUNTY FRAME 2

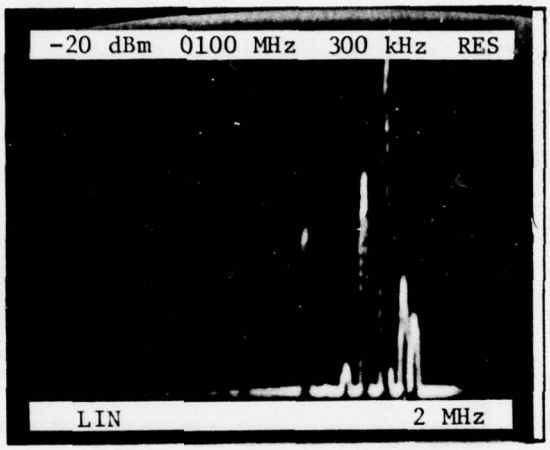
LOCATION - RNAV Rwy 29R, over middle marker

AUDIO INTERFERENCES

BENDIX-None

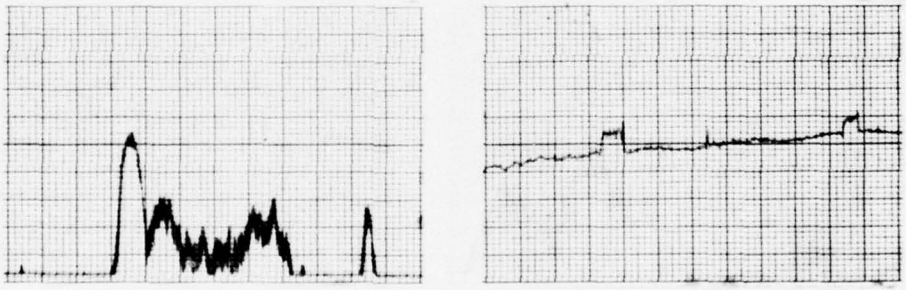
MARK 12-Music

FM SPECTRUM

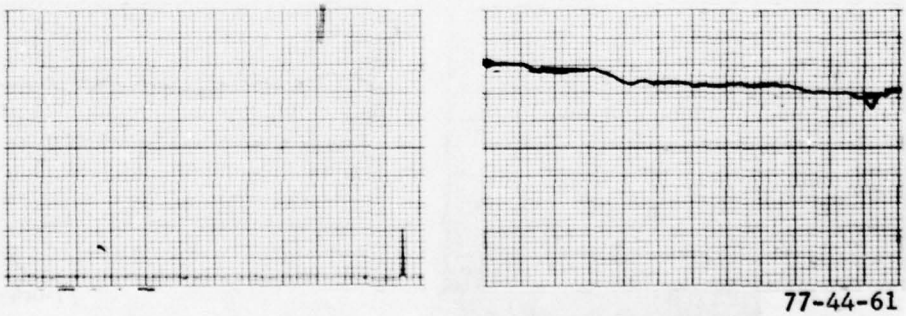


CDI AGC

MARK 12



BENDIX



77-44-61

FIGURE 61. DENVER - JEFFERSON COUNTY FRAME 3

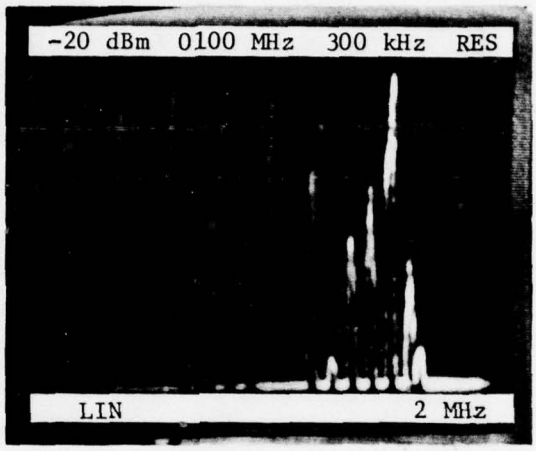
LOCATION - RNAV Rwy 29R, over outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

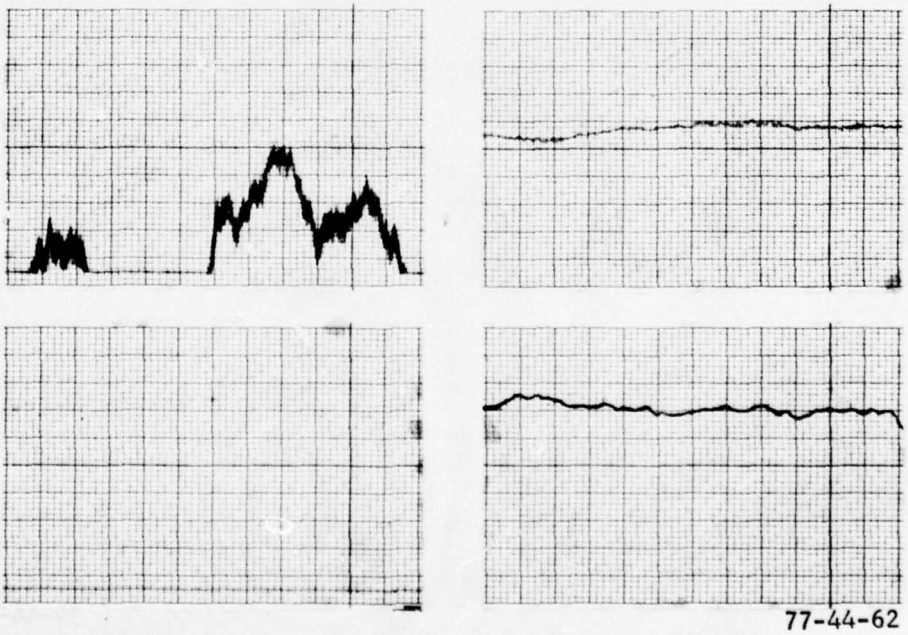
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-62

FIGURE 62. DENVER - JEFFERSON COUNTY FRAME 4

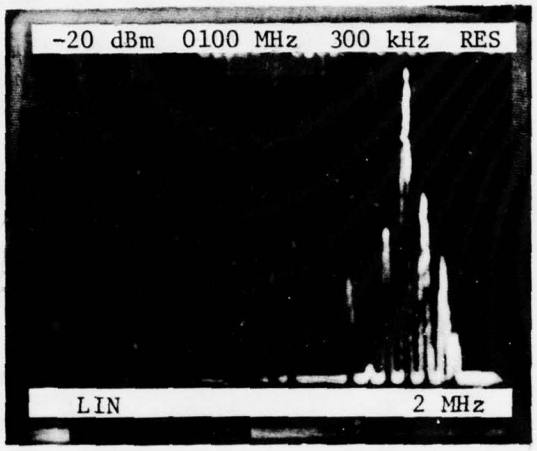
LOCATION - 260°R/14 nmi from Denver VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- High Background Noise

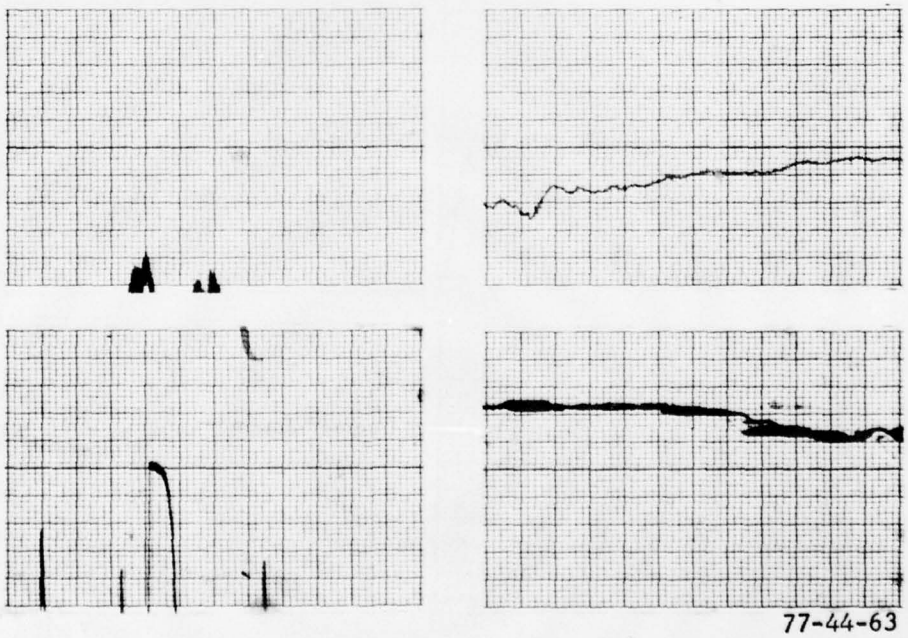
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-63

FIGURE 63. DENVER - JEFFERSON COUNTY FRAME 5

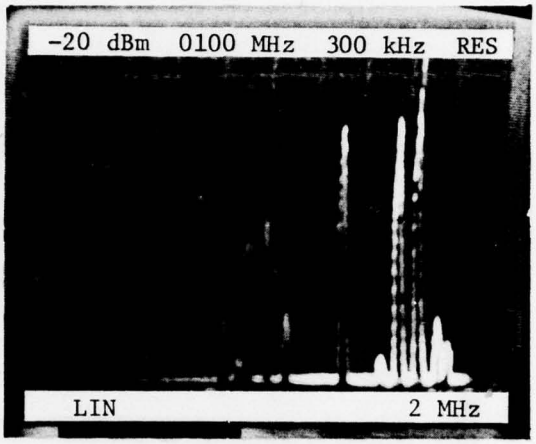
LOCATION - 258°R/13.5 nmi from Denver VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- High Background Noise

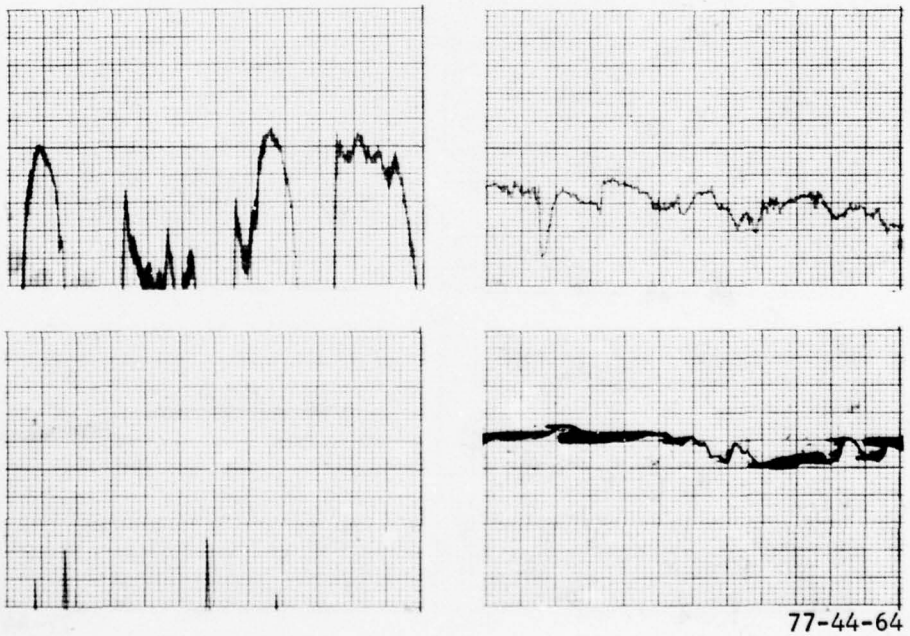
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-64

FIGURE 64. DENVER - JEFFERSON COUNTY FRAME 6

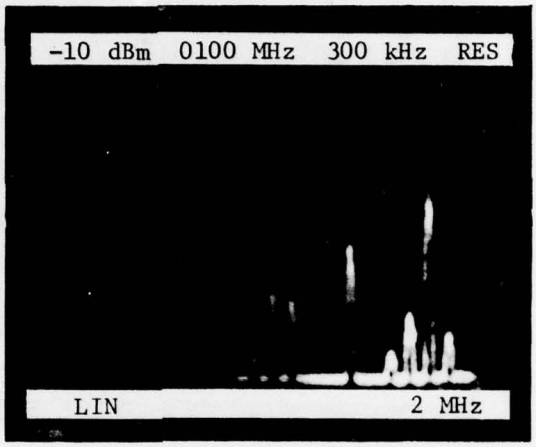
LOCATION - 240°/25 nmi from Denver VORTAC, Over ANTENNA #4

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

FM SPECTRUM

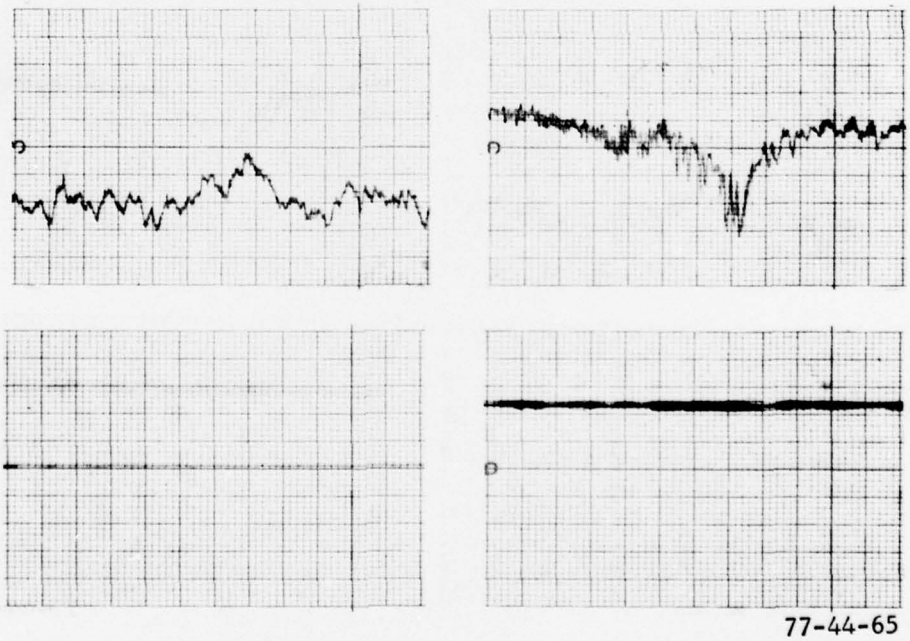


CDI

AGC

MARK 12

BENDIX



77-44-65

FIGURE 65. DENVER - JEFFERSON COUNTY FRAME 7

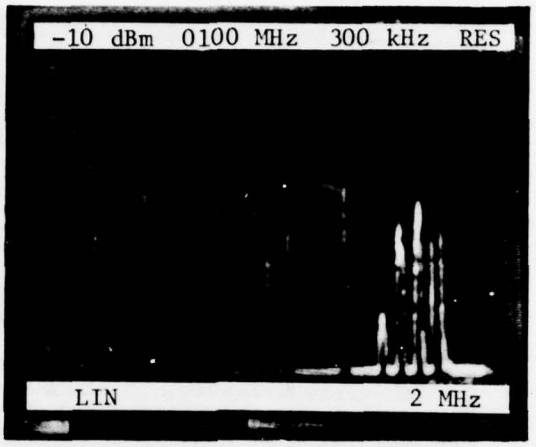
LOCATION - 230°R/20 nmi from Denver VORTAC, over ANTENNA A

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

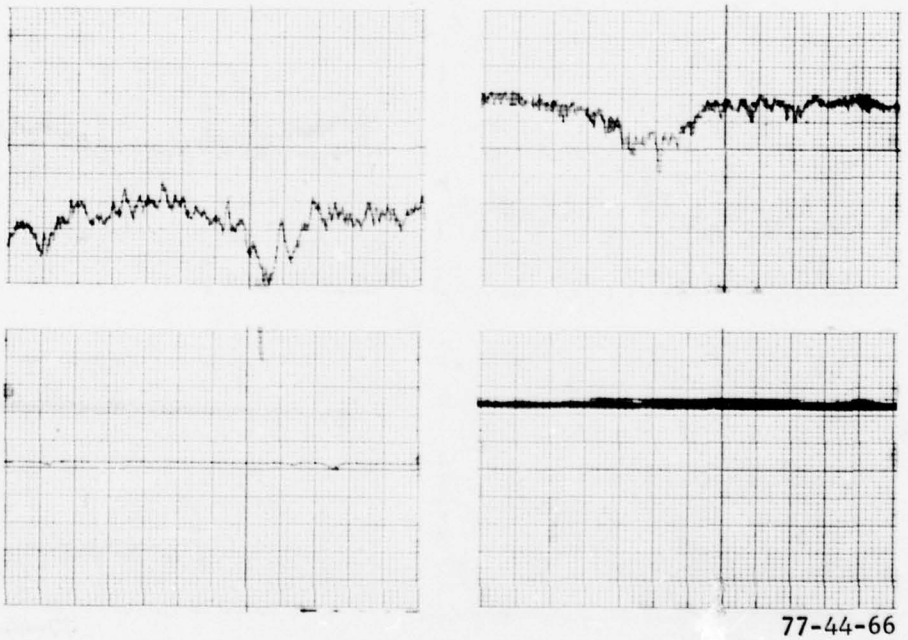
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-66

FIGURE 66. DENVER - JEFFERSON COUNTY FRAME 8

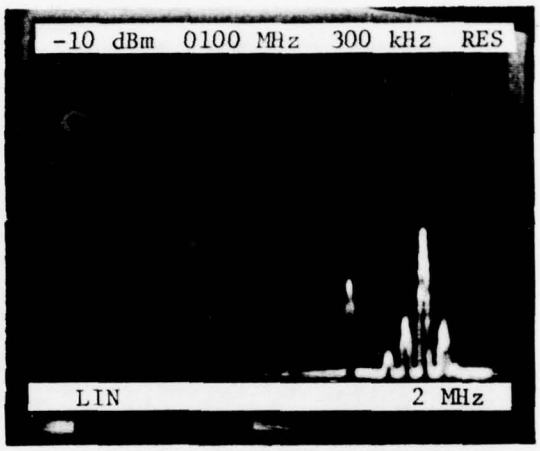
LOCATION - 250°R/19 nmi from Denver VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

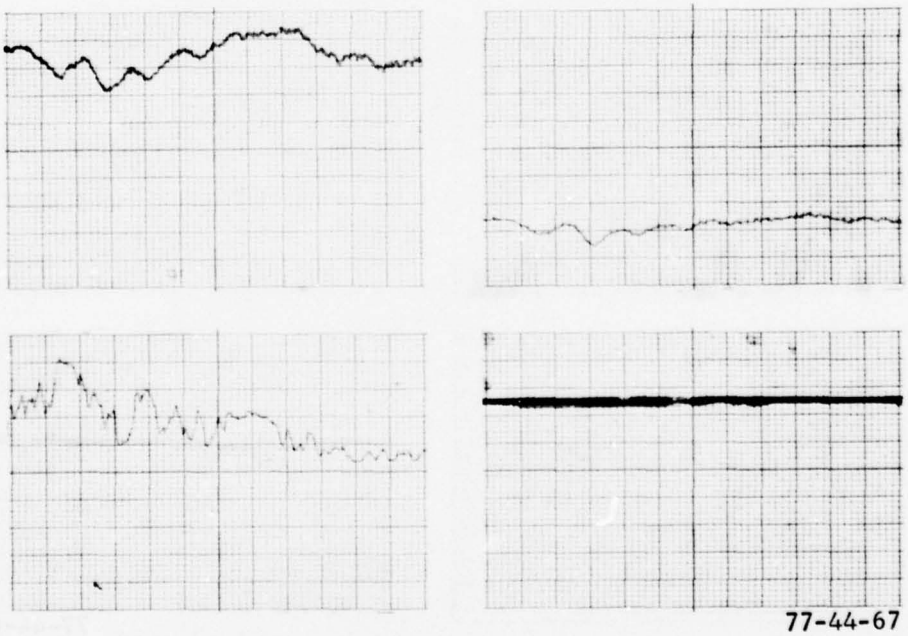
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-67

FIGURE 67. DENVER - JEFFERSON COUNTY FRAME 9

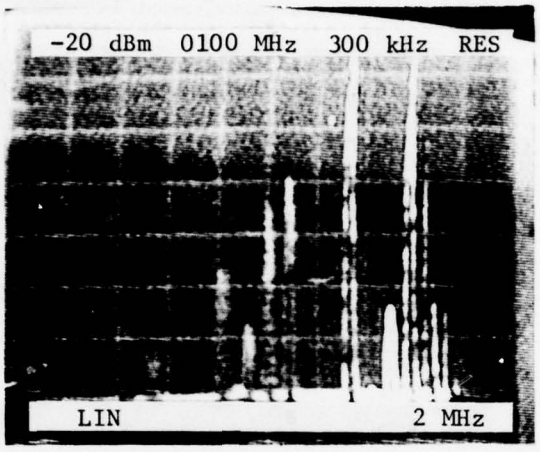
LOCATION - 230°/25.5 nmi from Denver VORTAC, over ANTENNA #4

AUDIO INTERFERENCES

BENDIX- None

MARK 12- High Background Noise

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-68

FIGURE 68. DENVER - JEFFERSON COUNTY FRAME 10

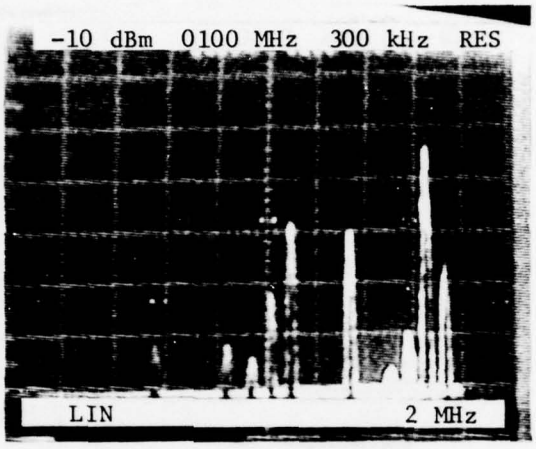
LOCATION - 230°R/21 nmi from Denver VORTAC, over ANTENNA A

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

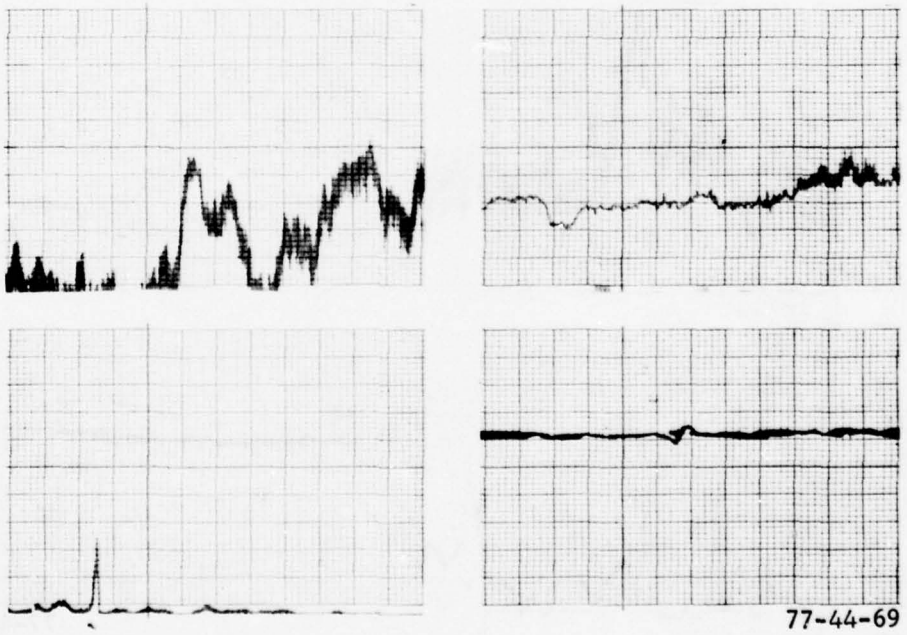


FIGURE 69. DENVER - JEFFERSON COUNTY FRAME 11

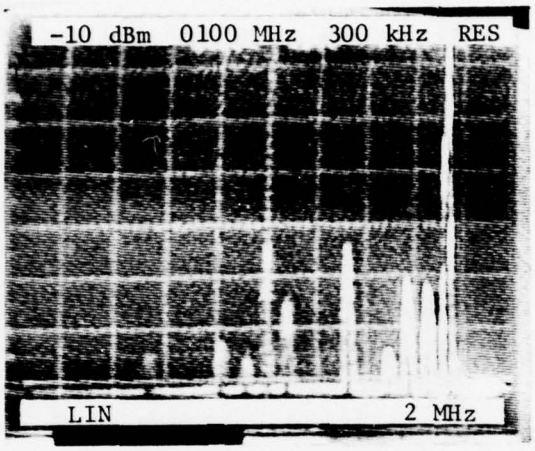
LOCATION - 220°R/21 nmi from Denver VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12-Distorted Voice

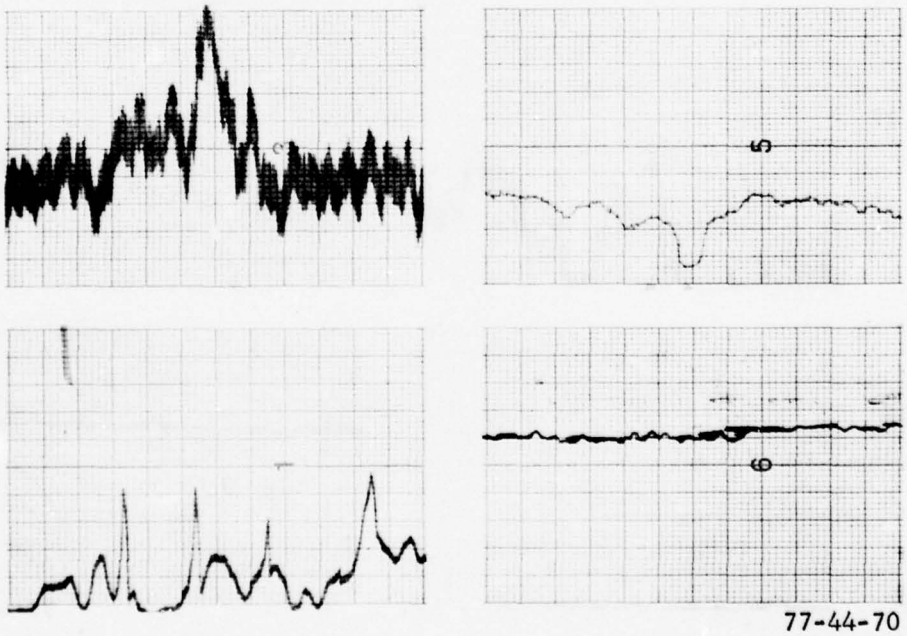
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-70

FIGURE 70. DENVER - JEFFERSON COUNTY FRAME 12

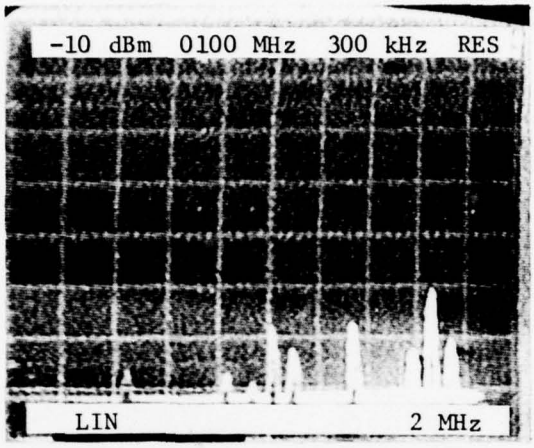
LOCATION - 270°R/18 nmi from Denver VORTAC, over ANTENNA #8

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating sound

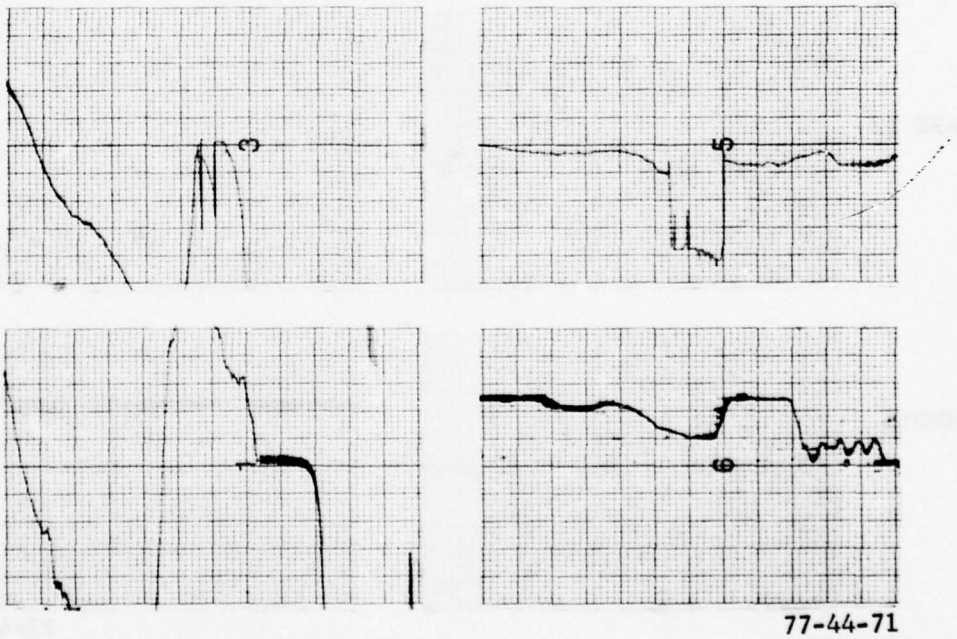
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-71

FIGURE 71. DENVER - JEFFERSON COUNTY FRAME 13

LOCATION - 235°R/22 nmi from Denver VORTAC, over ANTENNA A

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

FM SPECTRUM

Blank Video Recording

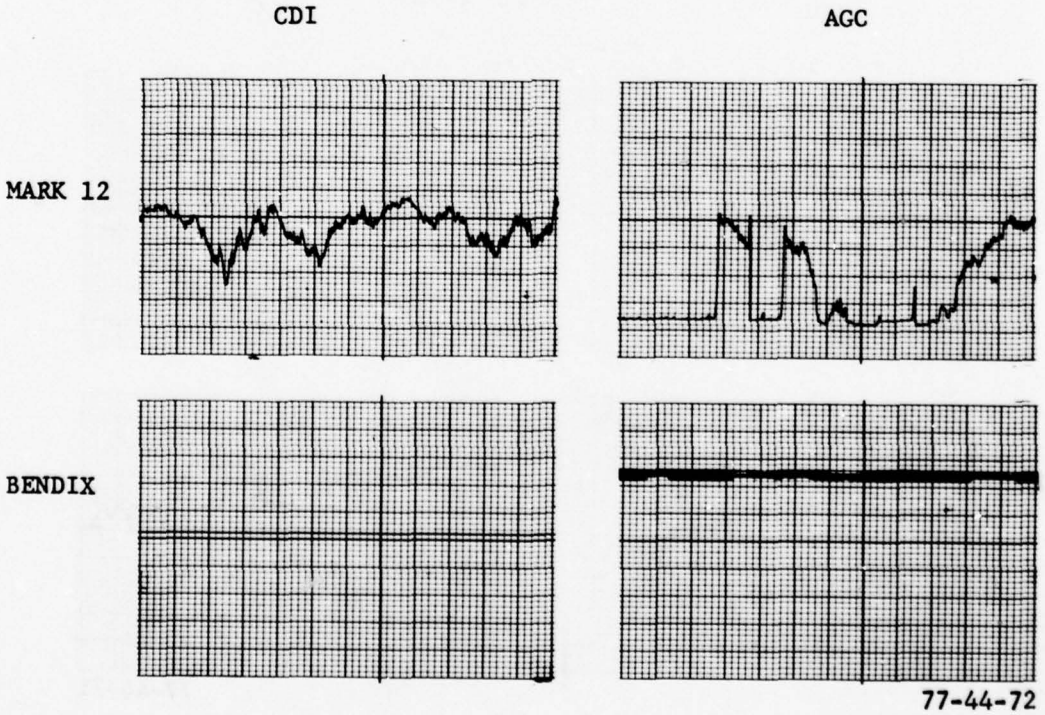


FIGURE 72. DENVER - JEFFERSON COUNTY FRAME 14

LOCATION - 060°/20 nmi from Denver VORTAC, over ANTENNA #4

AUDIO INTERFERENCES

BENDIX-
MARK 12-

Blank Recording

FM SPECTRUM

Blank Video Recording

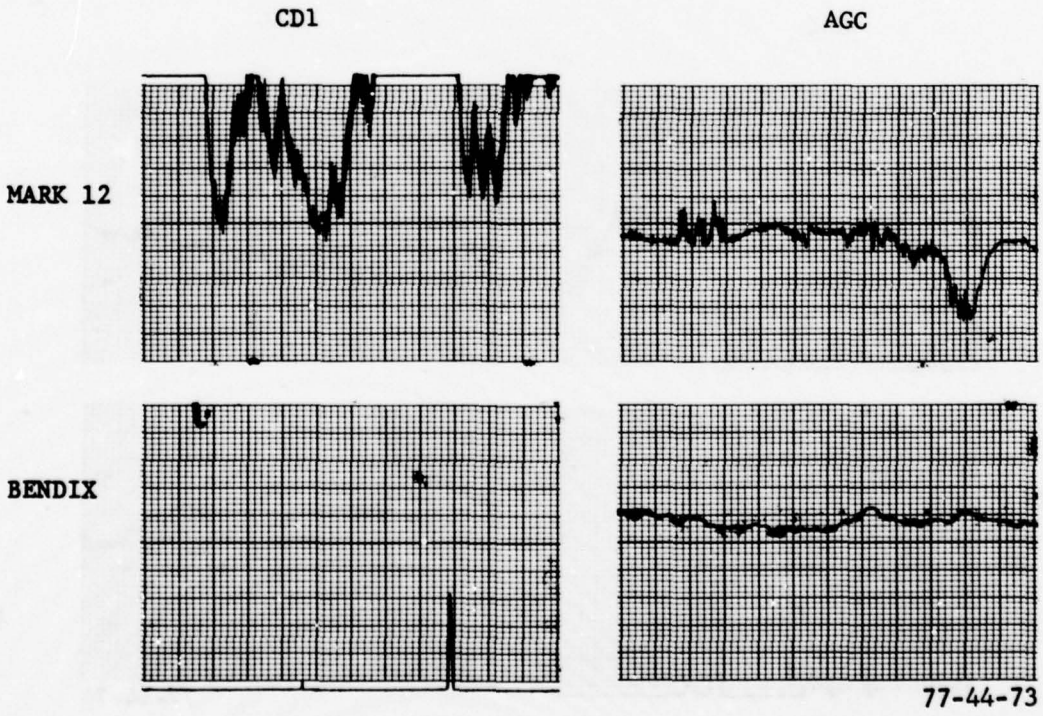


FIGURE 73. DENVER - JEFFERSON COUNTY FRAME 15

LOCATION - 050°/19 nmi from Denver VORTAC

AUDIO INTERFERENCES

BENDIX-

MARK 12-

Blank Recording

FM SPECTRUM

Blank Video Recording

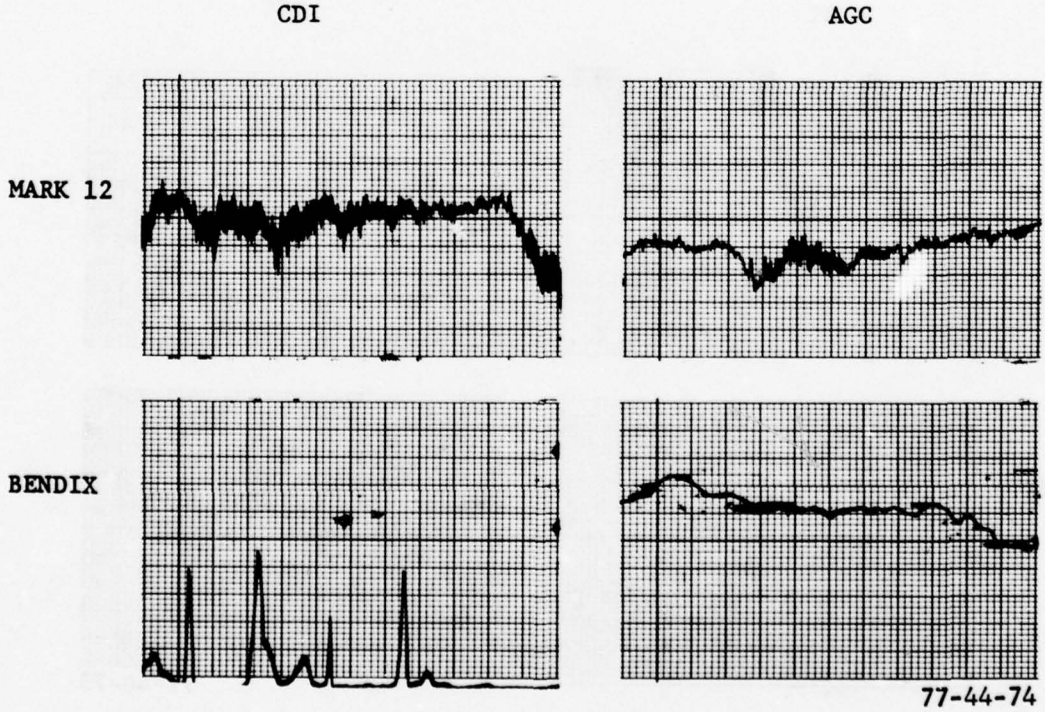


FIGURE 74. DENVER - JEFFERSON COUNTY FRAME 16

LOCATION - 050°R/20 nmi from airfield, between ANTENNAS #6 and #1

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Distorted Voice

FM SPECTRUM

Blank Video Recording

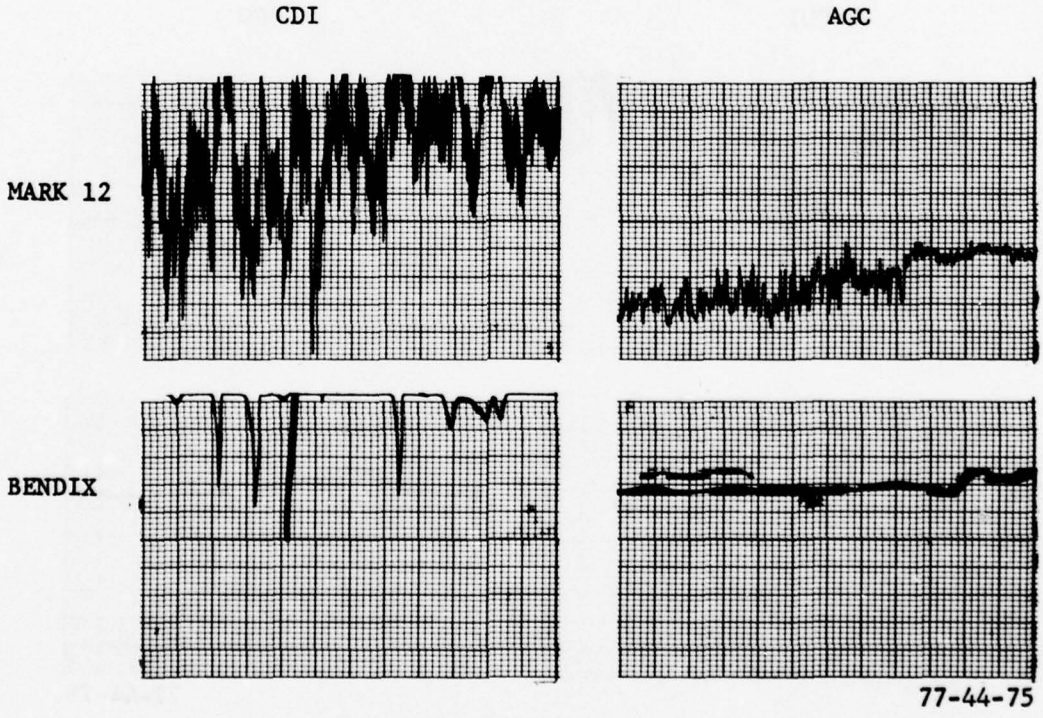


FIGURE 75. ALBUQUERQUE - INTERNATIONAL FRAME 1

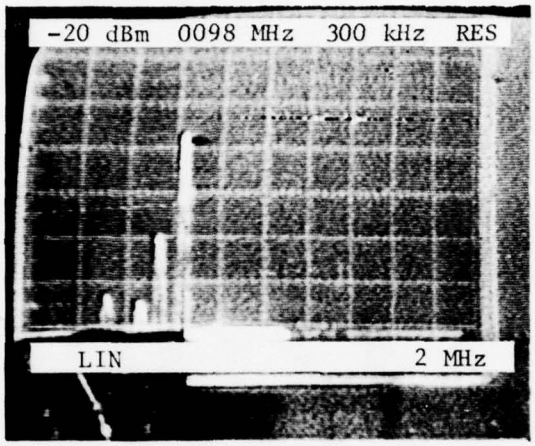
LOCATION - 060°R/20 nmi from airport, between ANTENNAS #1 and #2

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Distorted Voice

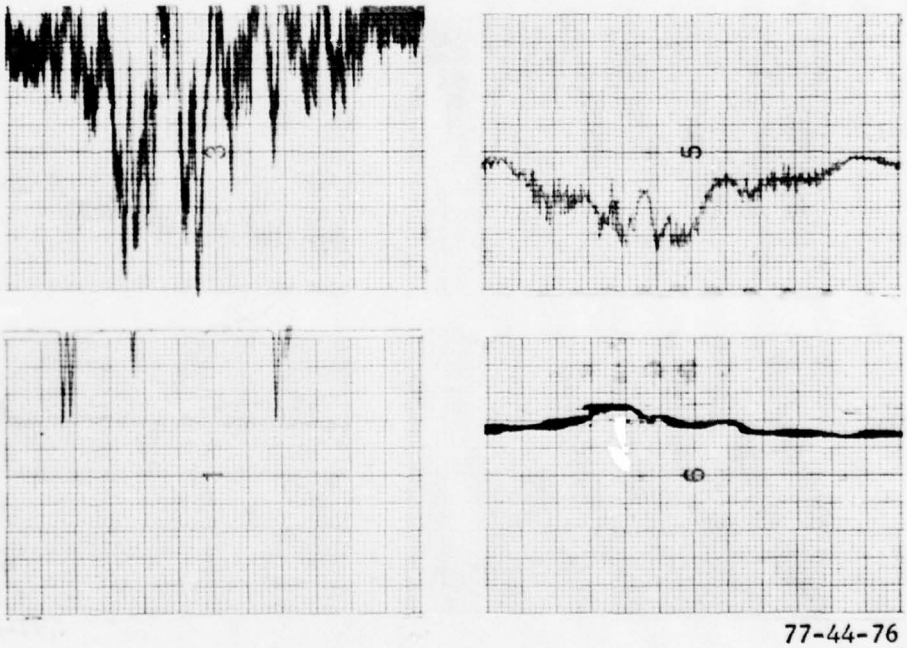
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-76

FIGURE 76. ALBUQUERQUE - INTERNATIONAL FRAME 2

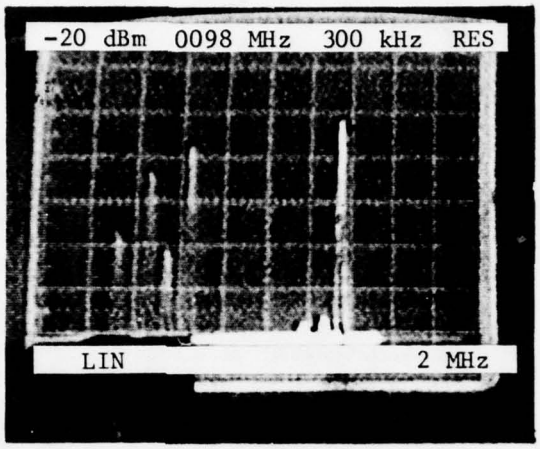
LOCATION - 040°R/20 nmi from airport

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Distorted Voice

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-77

FIGURE 77. ALBUQUERQUE - INTERNATIONAL FRAME 3

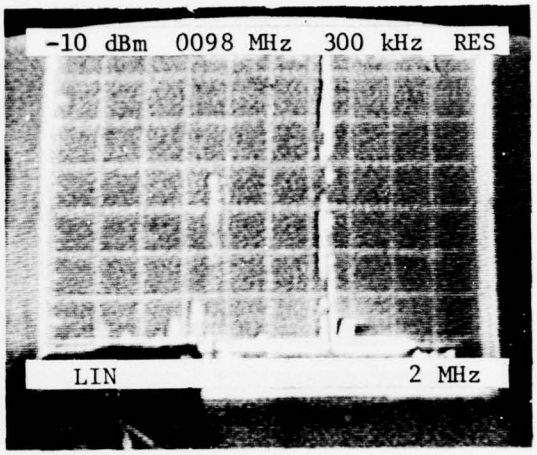
LOCATION - 063°R/9 nmi from Albuquerque VORTAC

AUDIO INTERFERENCES

BENDIX- Motorboating Sound

MARK 12- Motorboating Sound

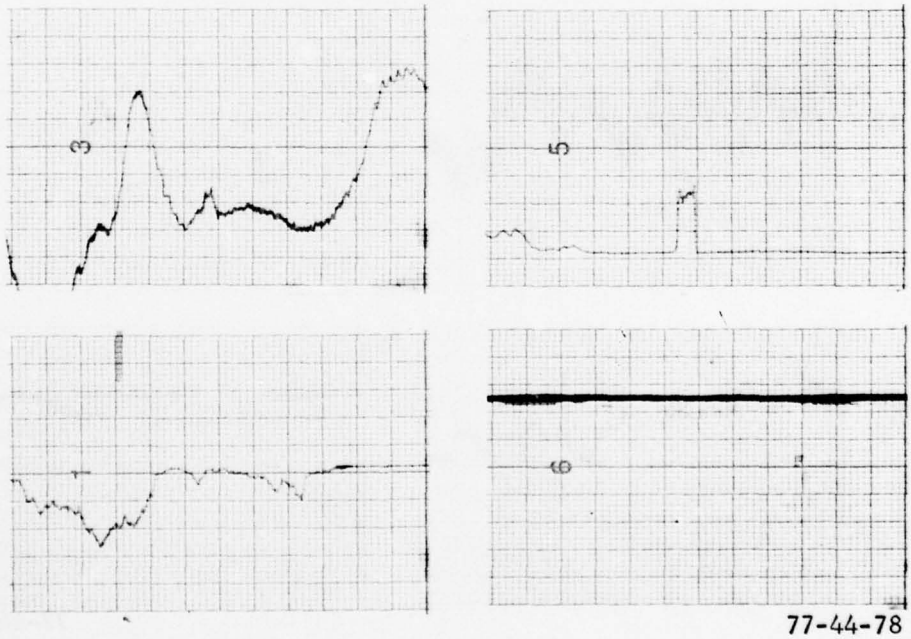
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-78

FIGURE 78. ALBUQUERQUE - INTERNATIONAL FRAME 4

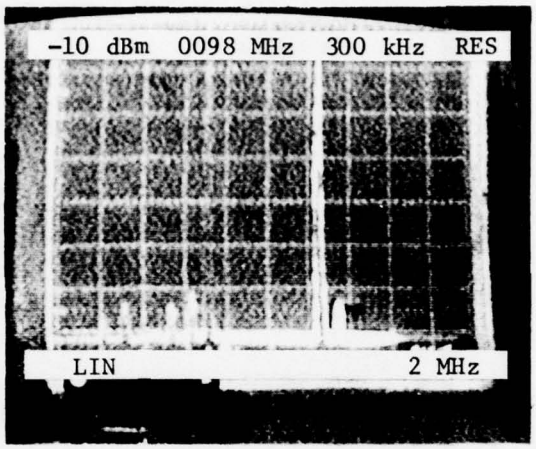
LOCATION - 063°R/7 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

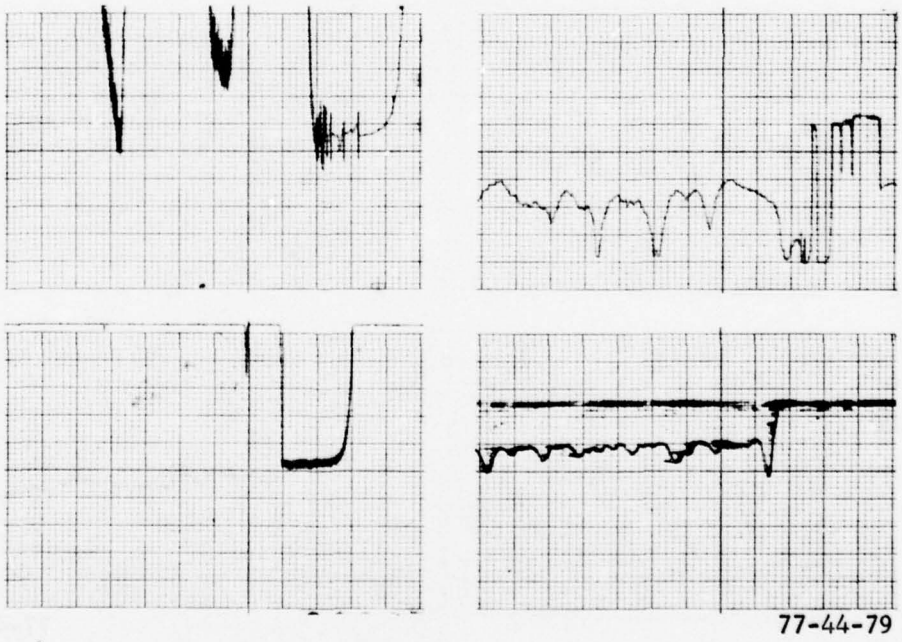
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-79

FIGURE 79. ALBUQUERQUE - INTERNATIONAL FRAME 5

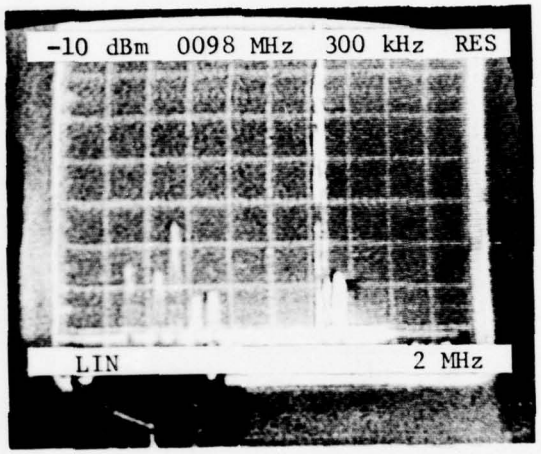
LOCATION - 063°R/12 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

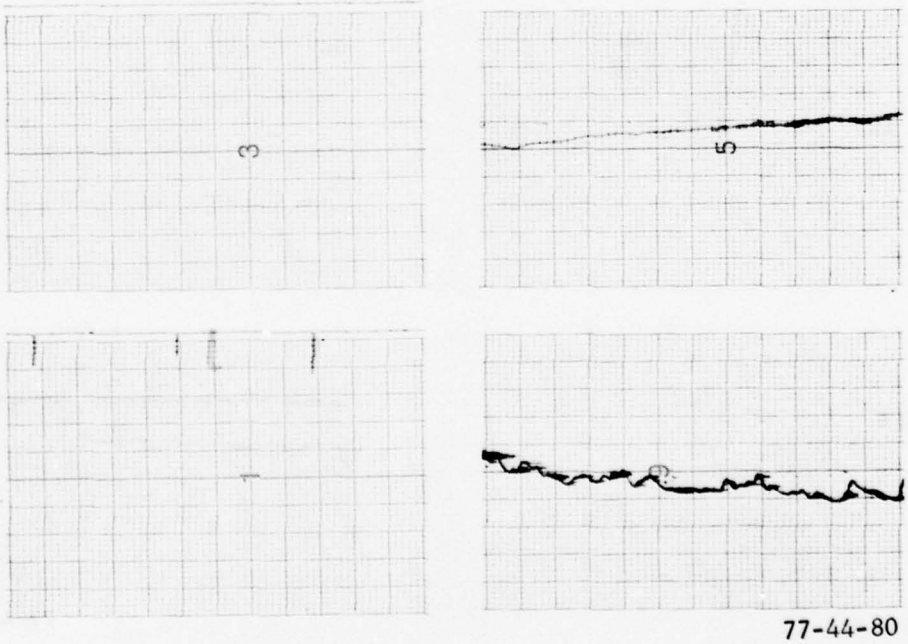
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-80

FIGURE 80. ALBUQUERQUE - INTERNATIONAL FRAME 6

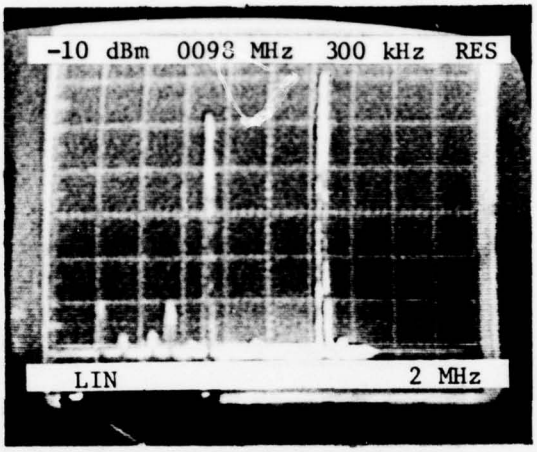
LOCATION - 063°R/12 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Distorted Voice

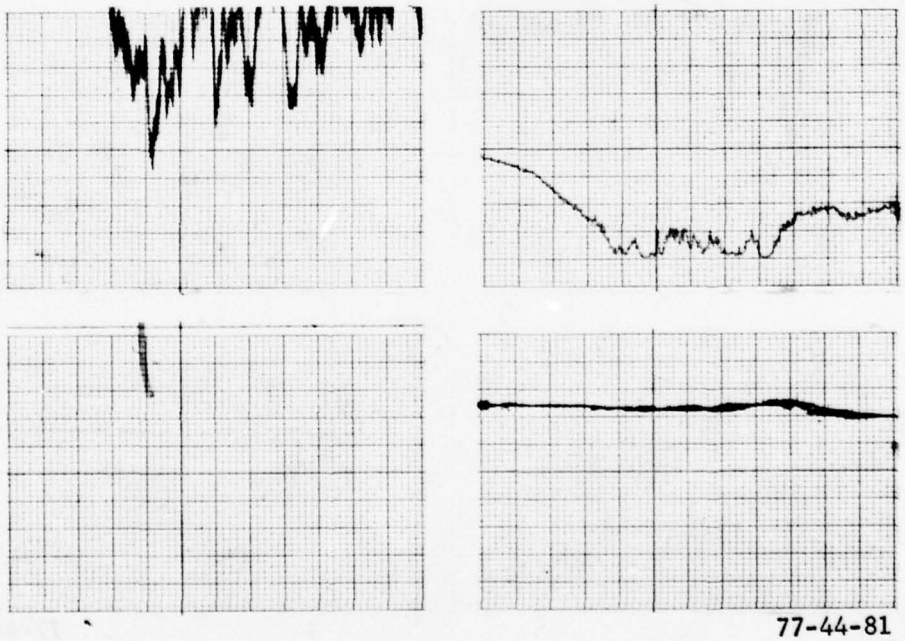
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-81

FIGURE 81. ALBUQUERQUE - INTERNATIONAL FRAME 7

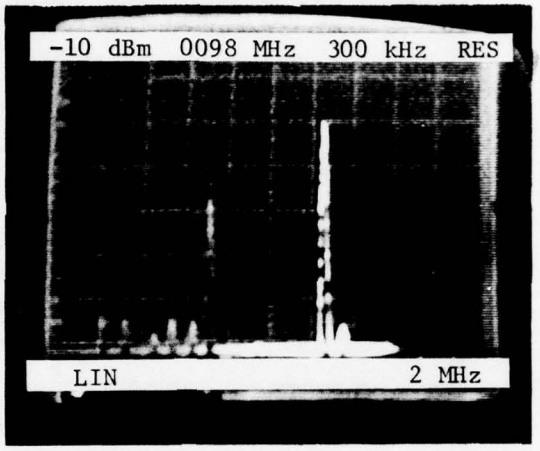
LOCATION - 063°R/8 nmi from VORTAC, over ANTENNA #4

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

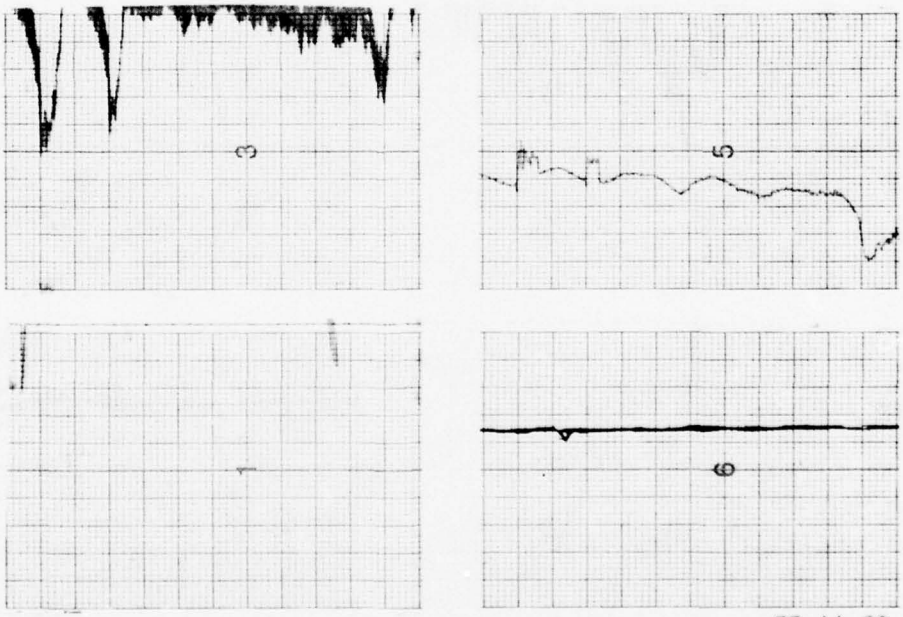
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-82

FIGURE 82. ALBUQUERQUE - INTERNATIONAL FRAME 8

LOCATION - 063°R/12 nmi from VORTAC, over ANTENNA #3

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating sound

FM SPECTRUM

Blank Video Recording

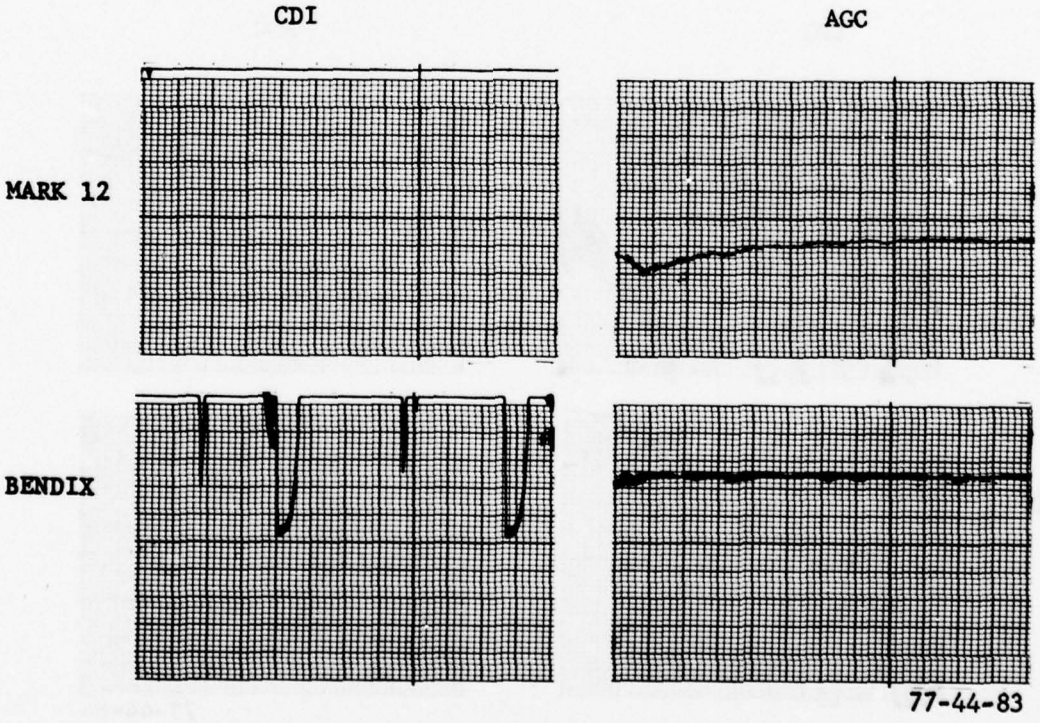


FIGURE 83. ALBUQUERQUE - INTERNATIONAL FRAME 9

LOCATION - 078°R/between outer marker and VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM

Blank Video Recording

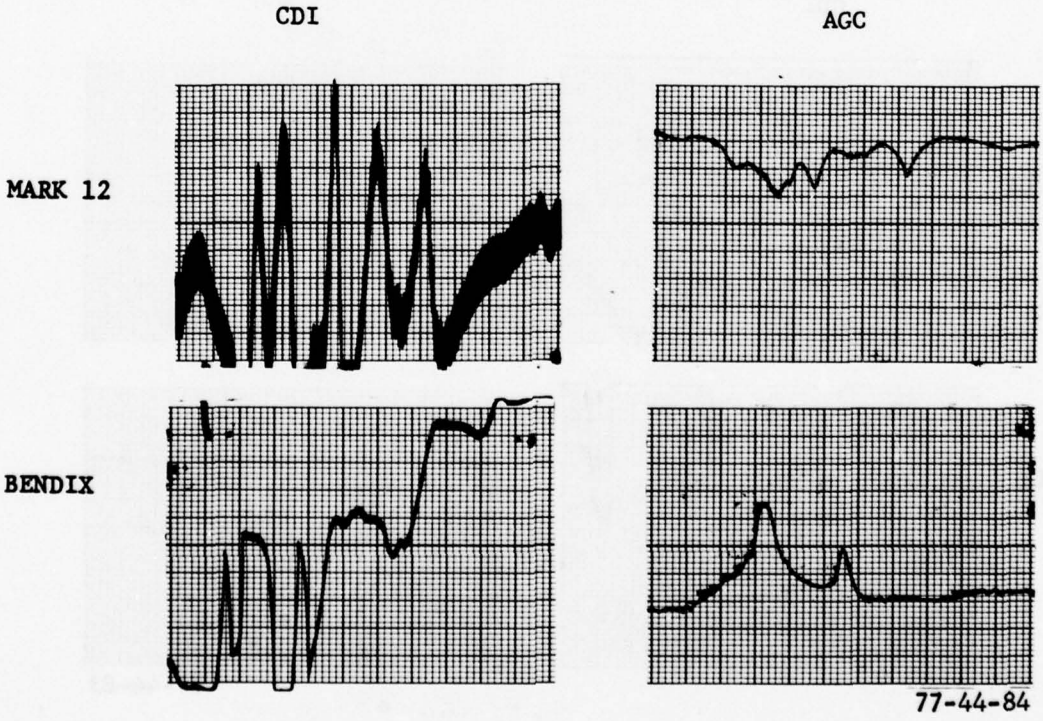


FIGURE 84. ALBUQUERQUE - INTERNATIONAL FRAME 10

LOCATION - 078°R/8 nmi

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM

Blank Video Recording

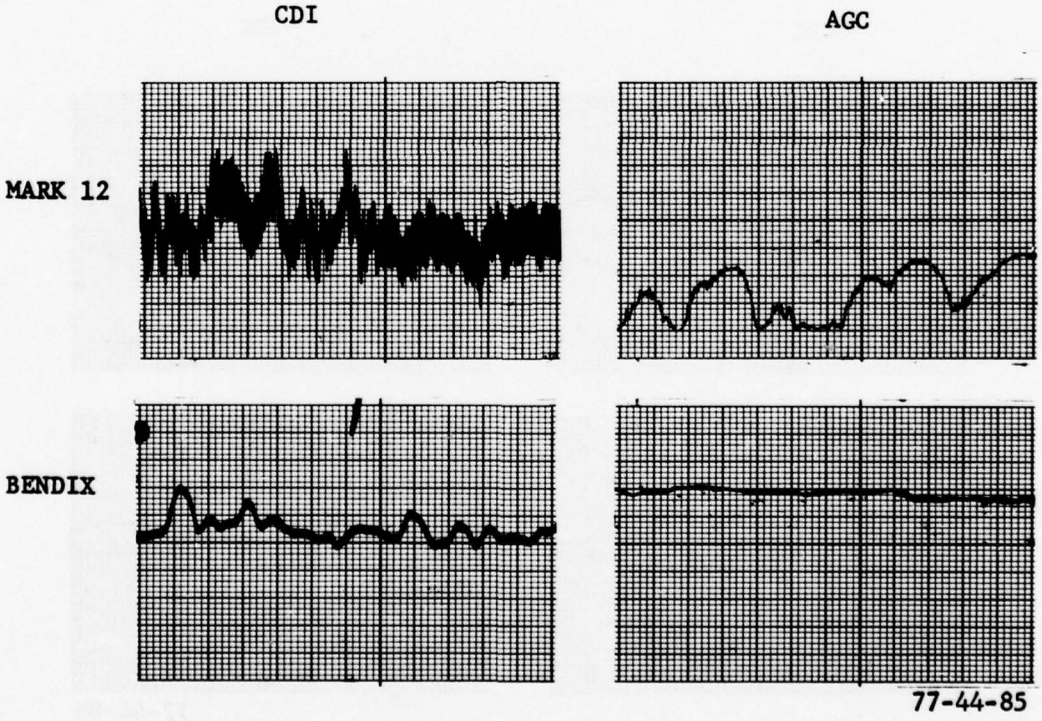


FIGURE 85. ALBUQUERQUE - INTERNATIONAL FRAME 11

LOCATION - Rwy 4, over VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM

Blank Video Recording

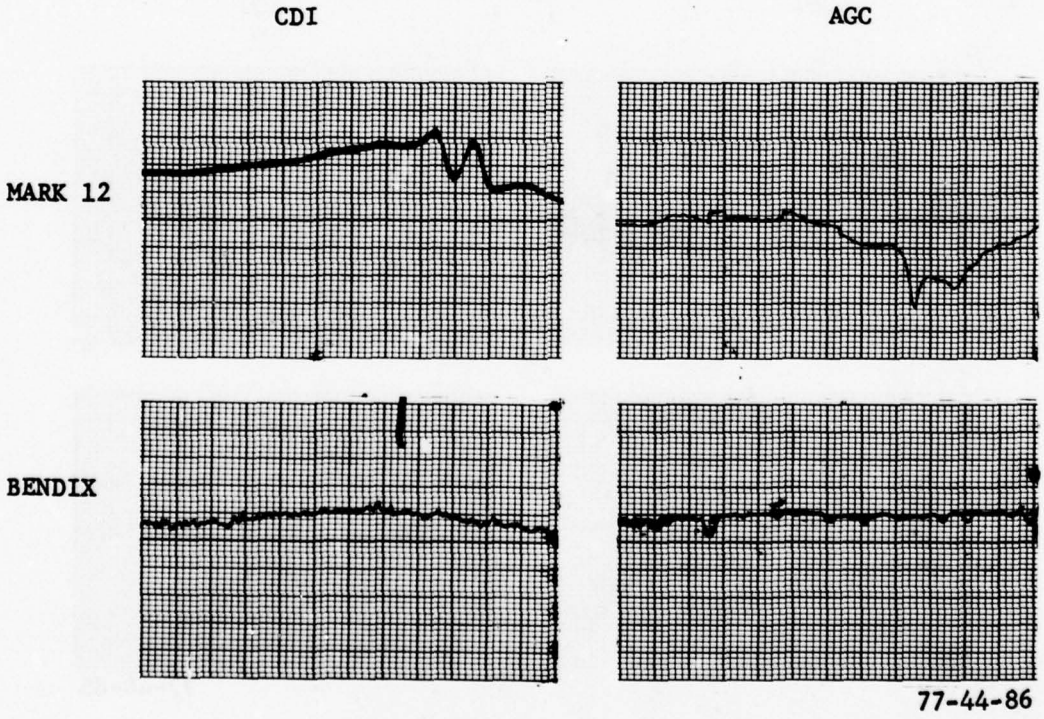


FIGURE 86. ALBUQUERQUE - INTERNATIONAL FRAME 12

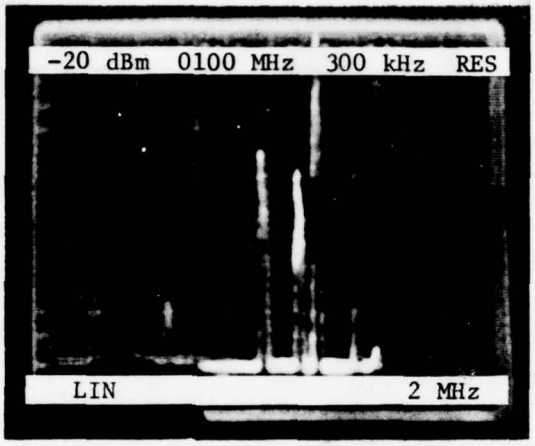
LOCATION - ½ nmi from outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

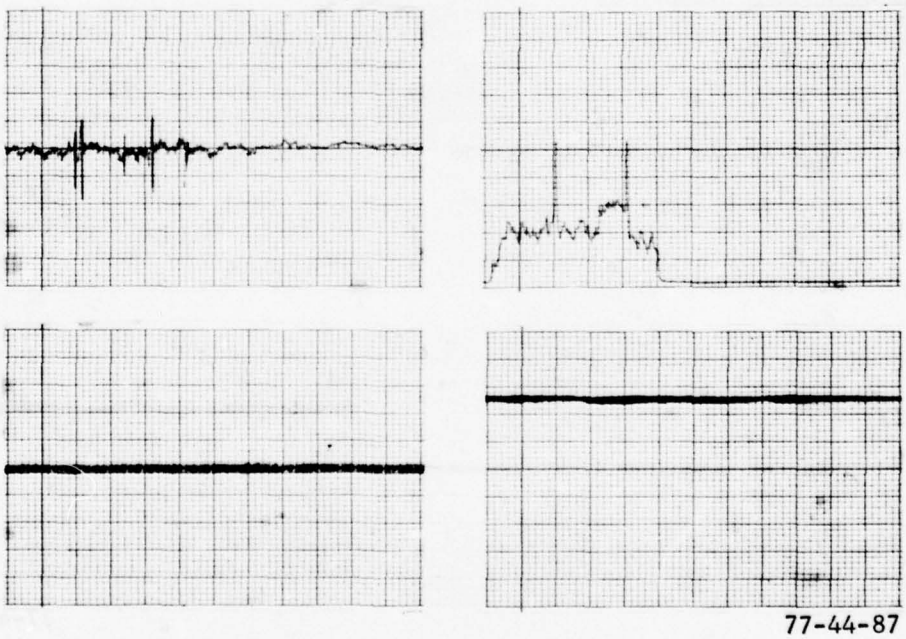
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-87

FIGURE 87. SAN ANTONIO - INTERNATIONAL FRAME 1

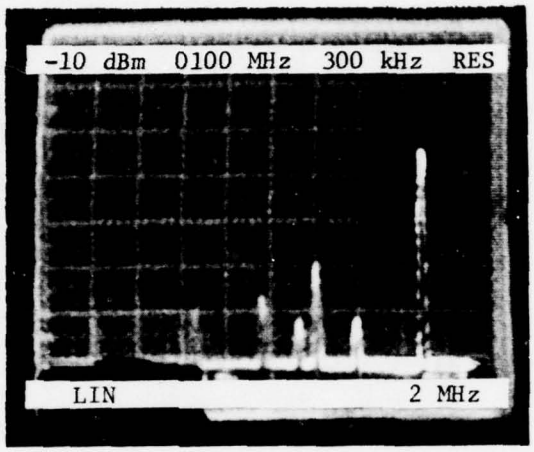
LOCATION - ½ nmi from outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM



CDI AGC

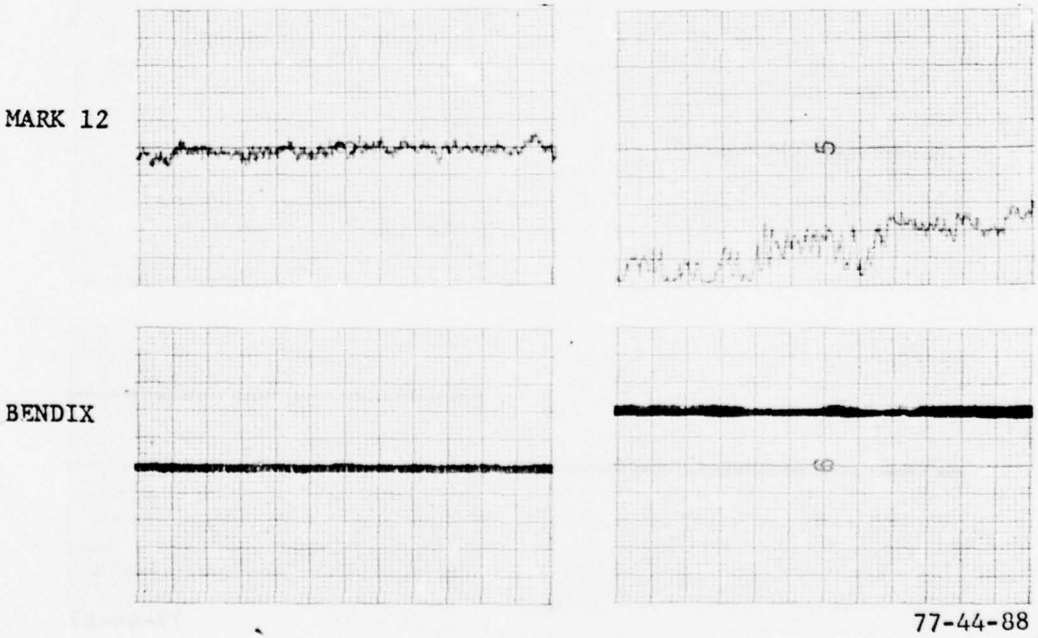


FIGURE 88. SAN ANTONIO - INTERNATIONAL FRAME 2

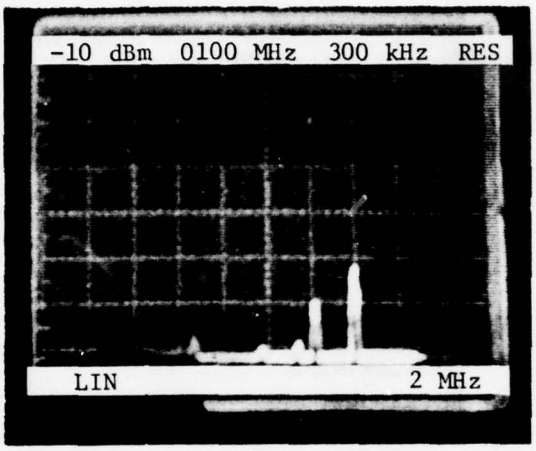
LOCATION - Over outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

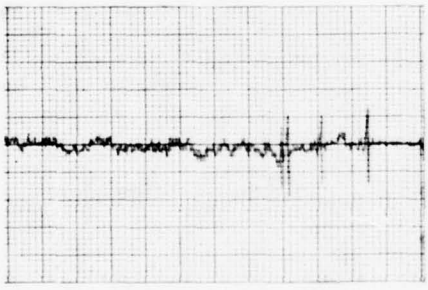
FM SPECTRUM

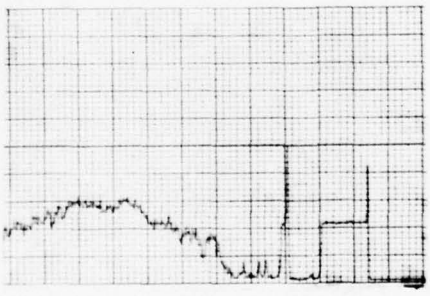


CDI

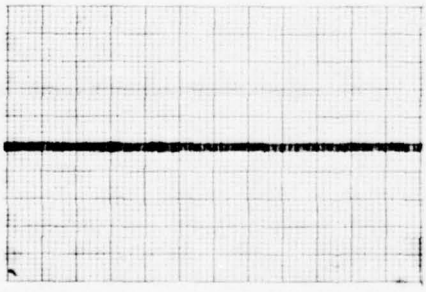
AGC

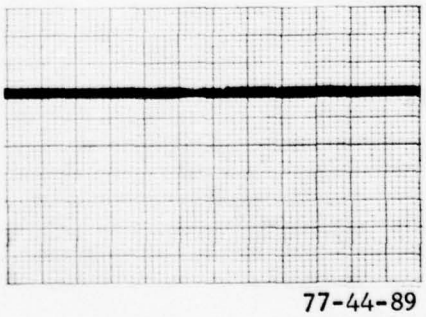
MARK 12





BENDIX





77-44-89

FIGURE 89. SAN ANTONIO - INTERNATIONAL FRAME 3

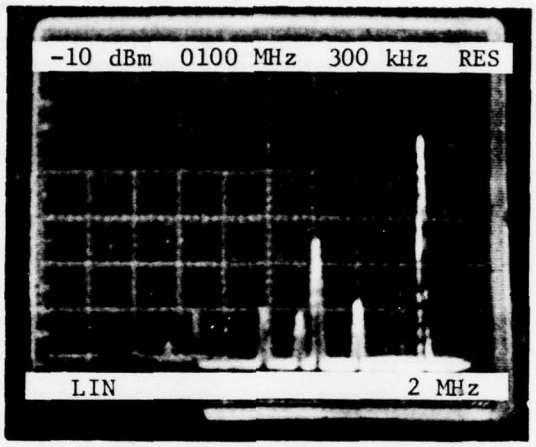
LOCATION - Over outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12-Music

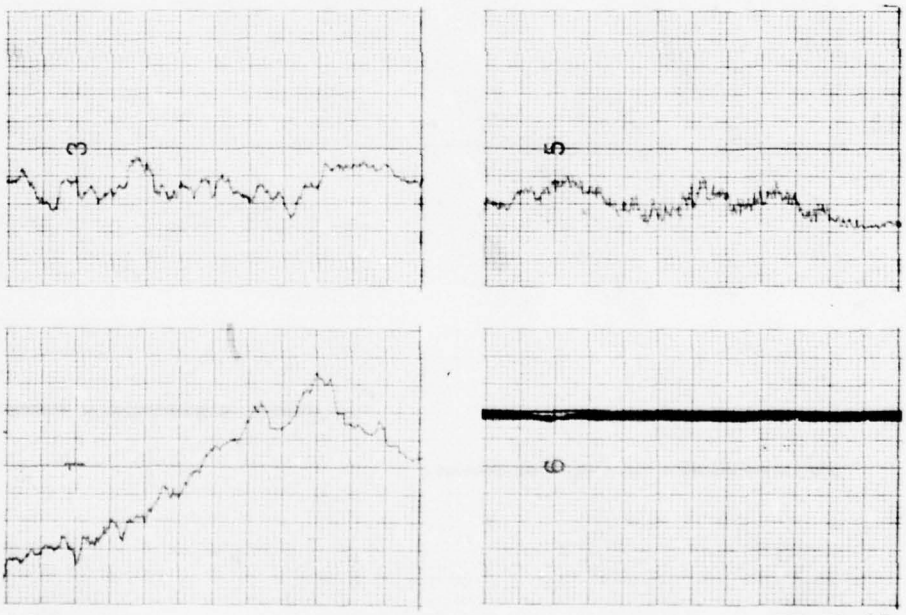
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-90

FIGURE 90. SAN ANTONIO - INTERNATIONAL FRAME 4

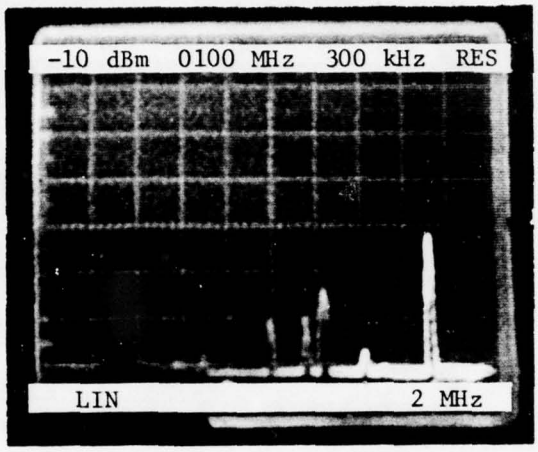
LOCATION - ½ nmi from outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-91

FIGURE 91. SAN ANTONIO - INTERNATIONAL FRAME 5

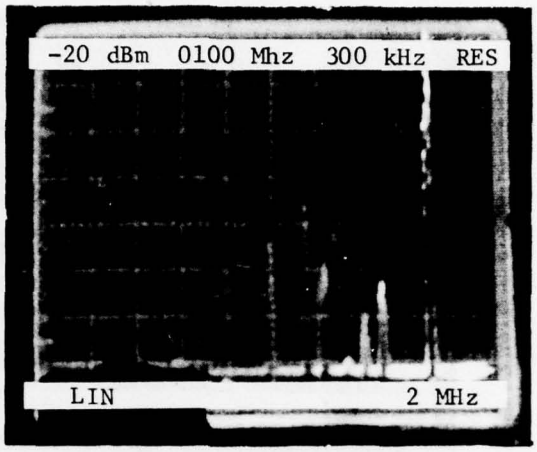
LOCATION - 1 nmi from outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-92

FIGURE 92. SAN ANTONIO - INTERNATIONAL FRAME 6

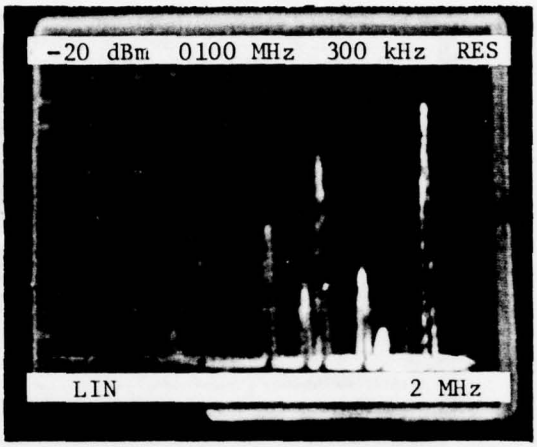
LOCATION - 177°R from San Antonio VORTAC, over ANTENNA #5

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

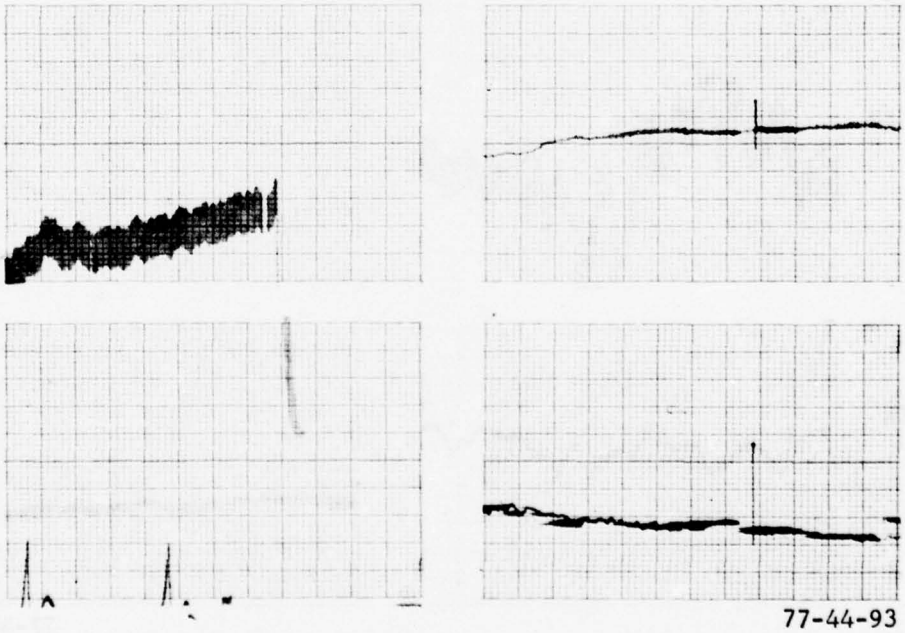
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-93

FIGURE 93. SAN ANTONIO - INTERNATIONAL FRAME 7

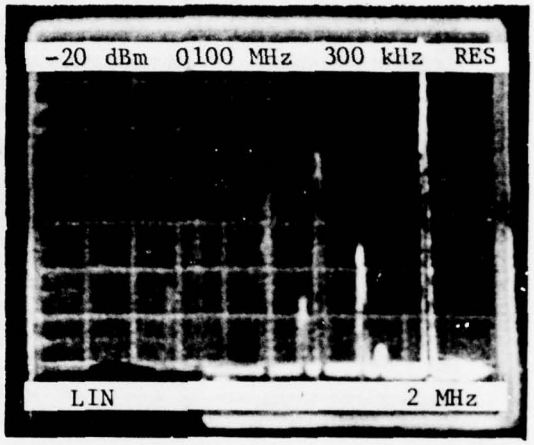
LOCATION - 177°R/7 nmi from VORTAC, over ANTENNA #2

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

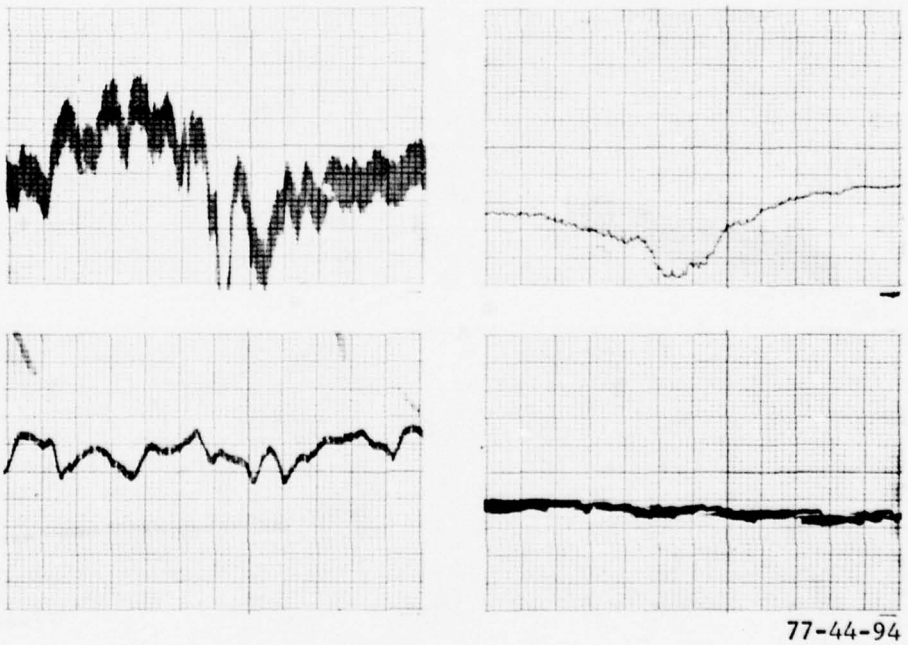
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-94

FIGURE 94. SAN ANTONIO - INTERNATIONAL FRAME 8

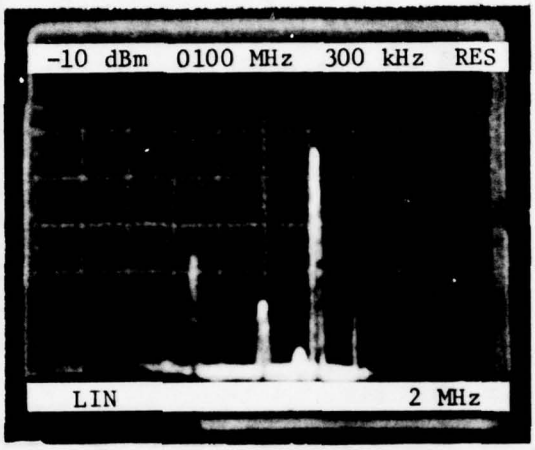
LOCATION - 12 nmi from VORTAC, over ANTENNA #5

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

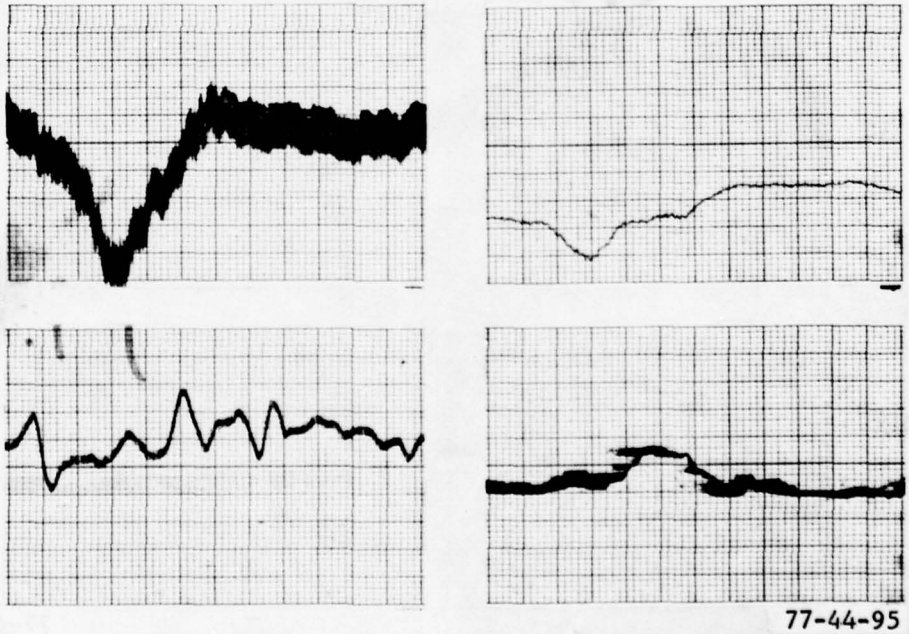
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-95

FIGURE 95. SAN ANTONIO - INTERNATIONAL FRAME 9

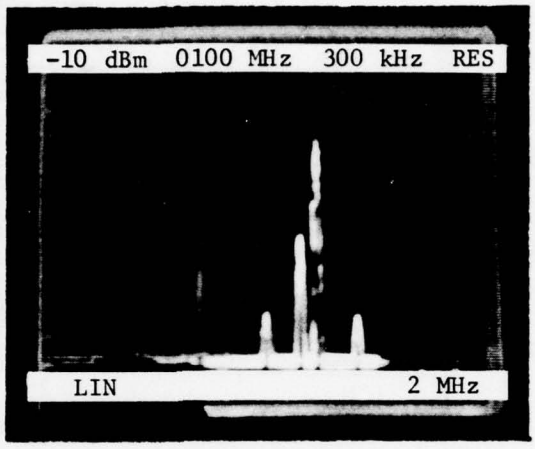
LOCATION - 177°R/14 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-96

FIGURE 96. SAN ANTONIO - INTERNATIONAL FRAME 10

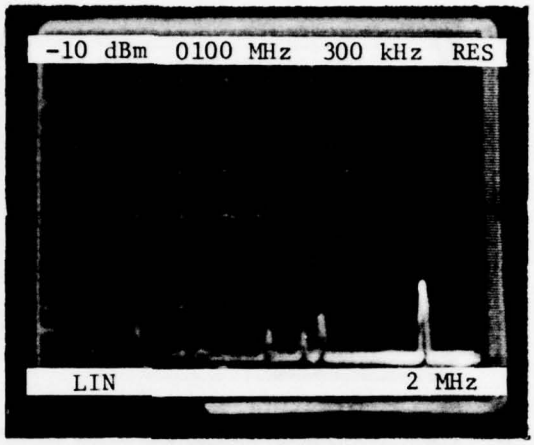
LOCATION - 177°R/15 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

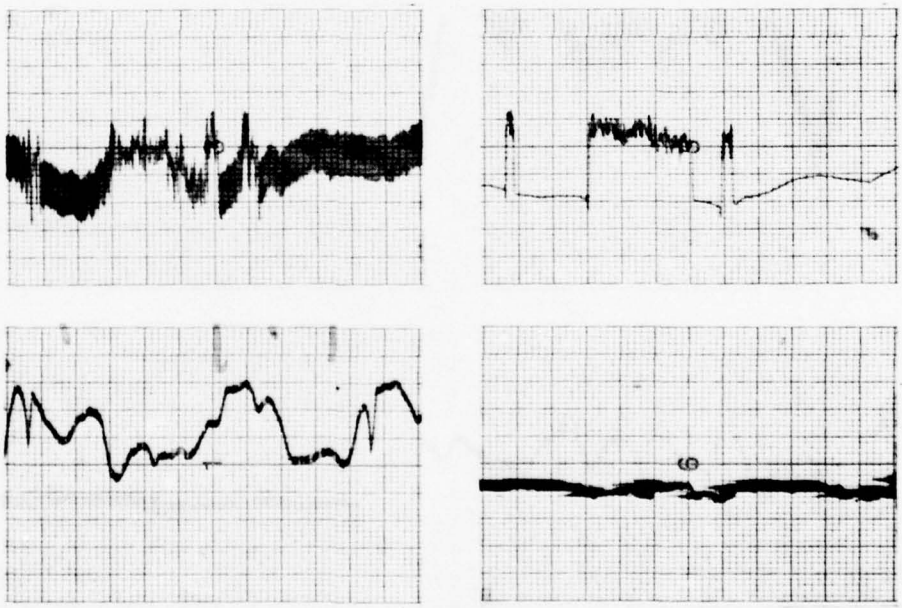
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-97

FIGURE 97. SAN ANTONIO - INTERNATIONAL FRAME 11

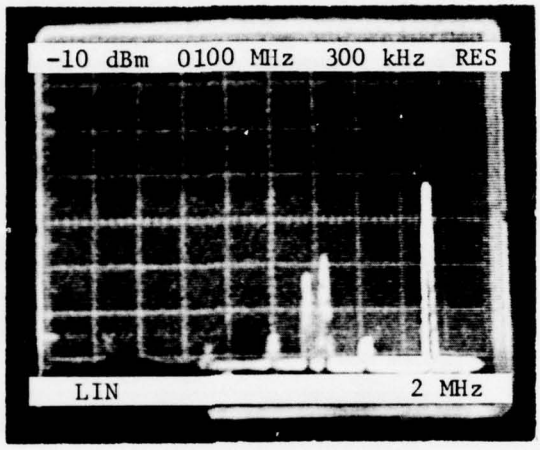
LOCATION - 13 nmi from VORTAC, over cluster of ANTENNAS

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

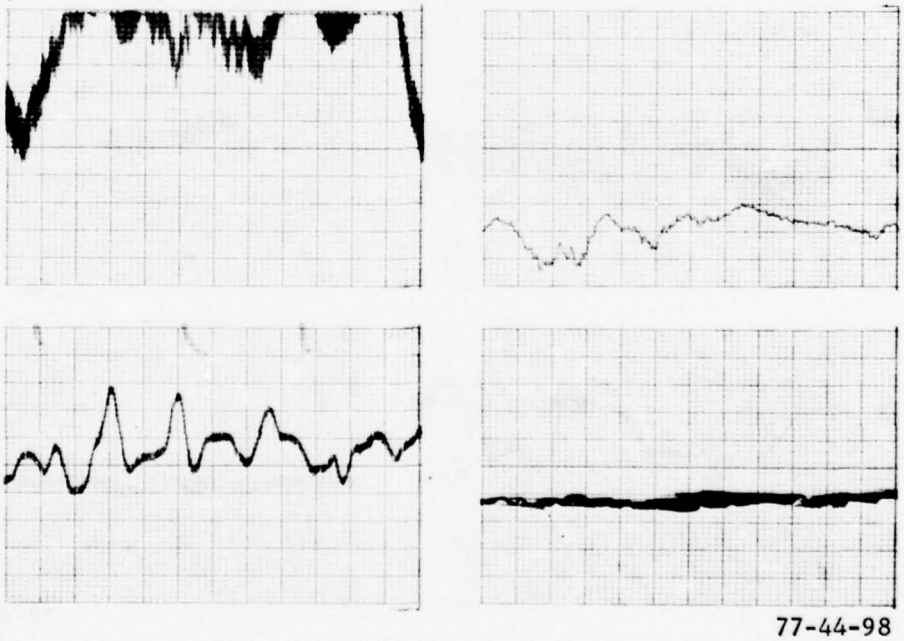
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-98

FIGURE 98. SAN ANTONIO - INTERNATIONAL FRAME 12

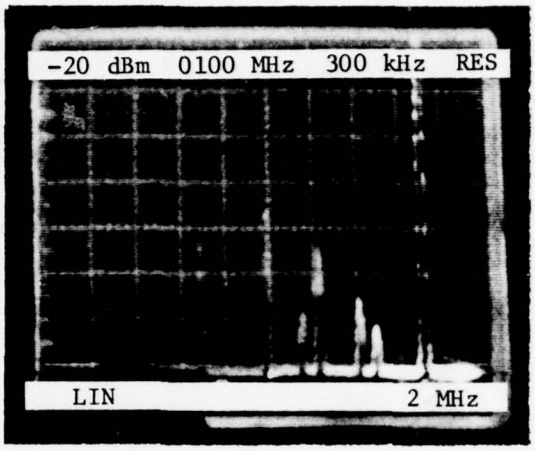
LOCATION - 158°R/6 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

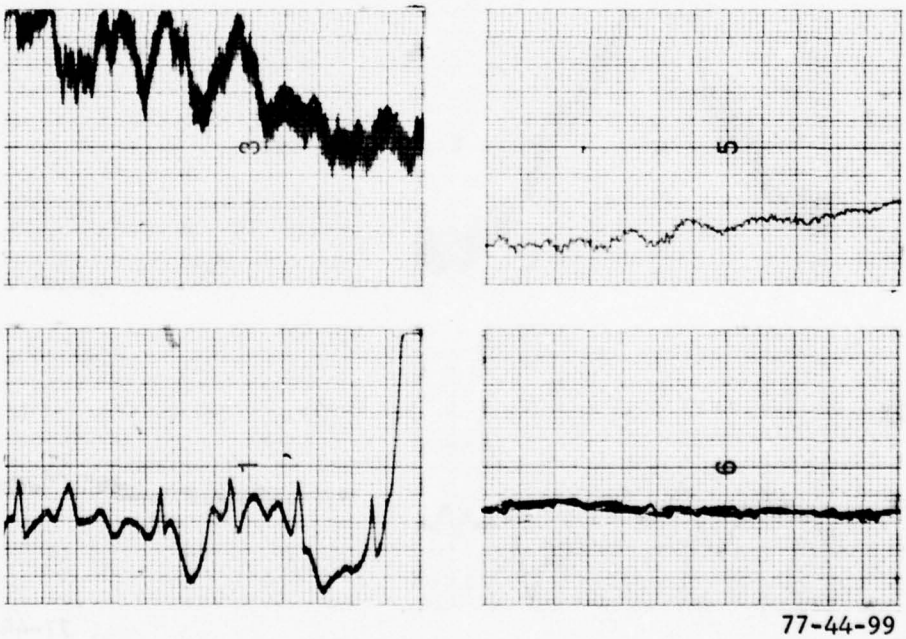
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-99

FIGURE 99. SAN ANTONIO - INTERNATIONAL FRAME 13

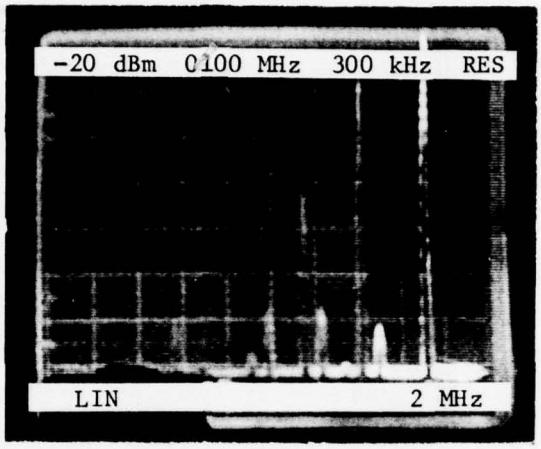
LOCATION - 158°R/9 nmi from VORTAC, over 4 ANTENNAS

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM

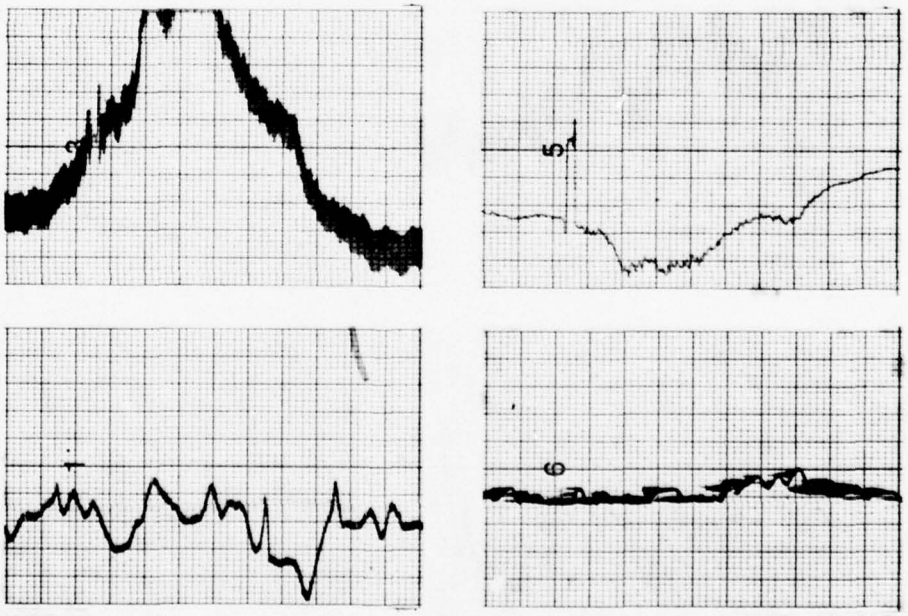


CDI

AGC

MARK 12

BENDIX



77-44-100

FIGURE 100. SAN ANTONIO - INTERNATIONAL FRAME 14

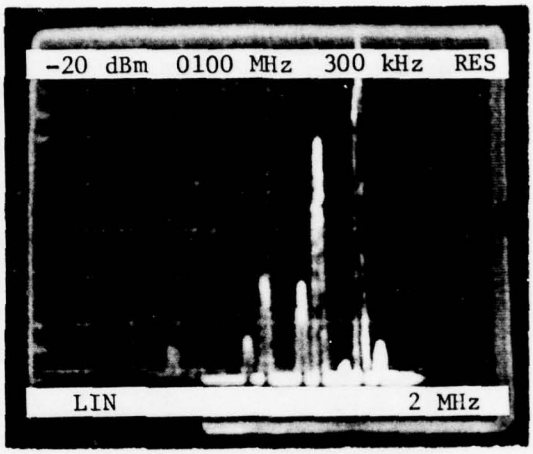
LOCATION - 158°R/16 nmi turning

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

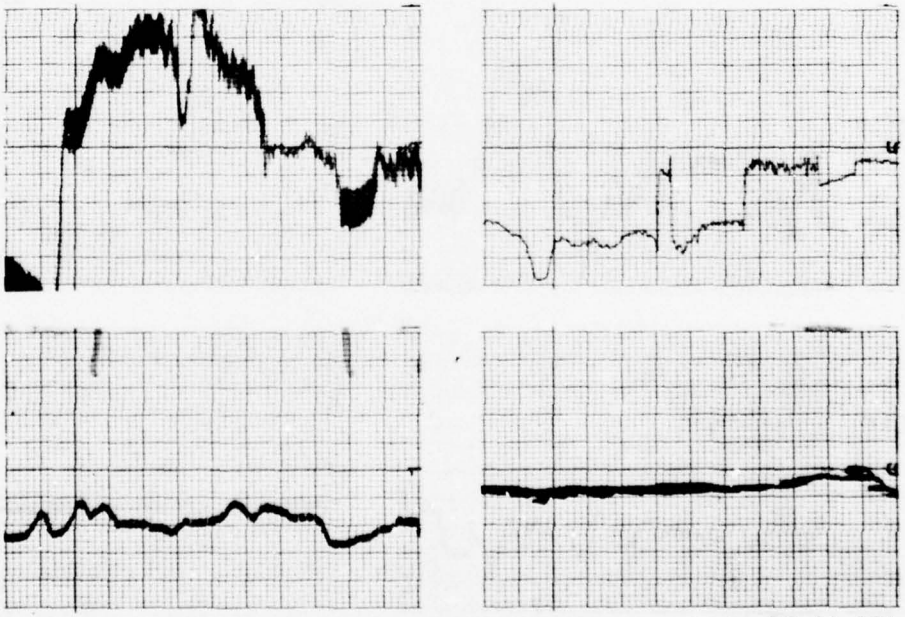
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-101

FIGURE 101. SAN ANTONIO - INTERNATIONAL FRAME 15

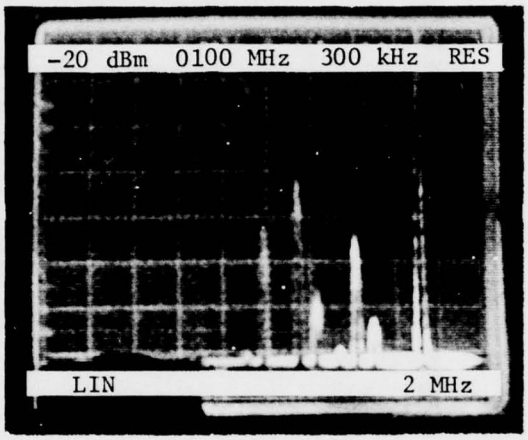
LOCATION - 158°R/13 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

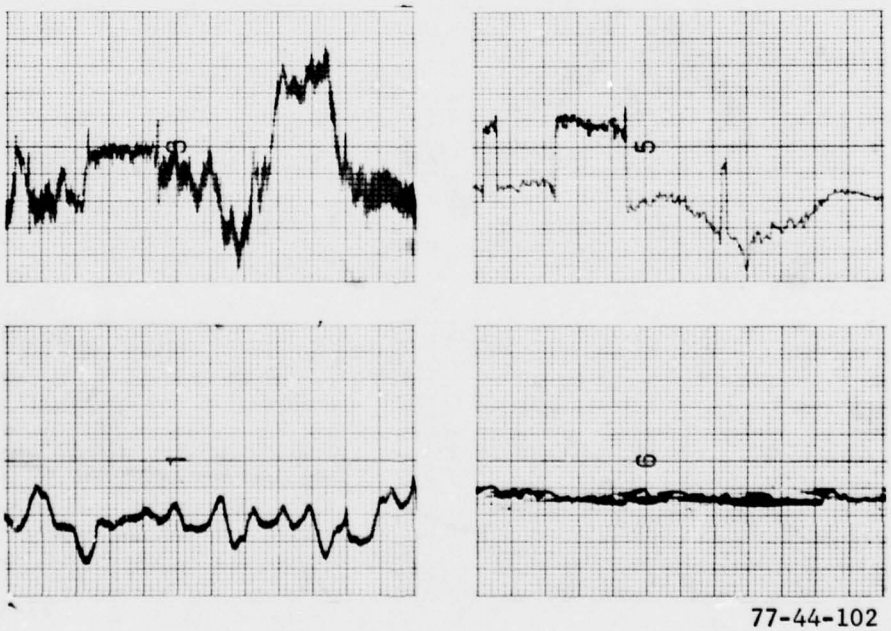
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-102

FIGURE 102. SAN ANTONIO - INTERNATIONAL FRAME 16

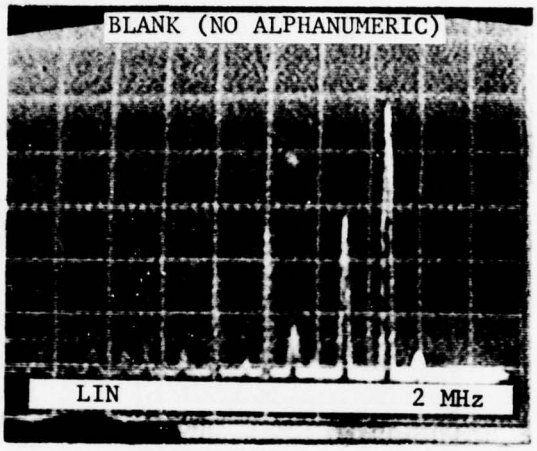
LOCATION - Rwy 13, 1 nmi outside of outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

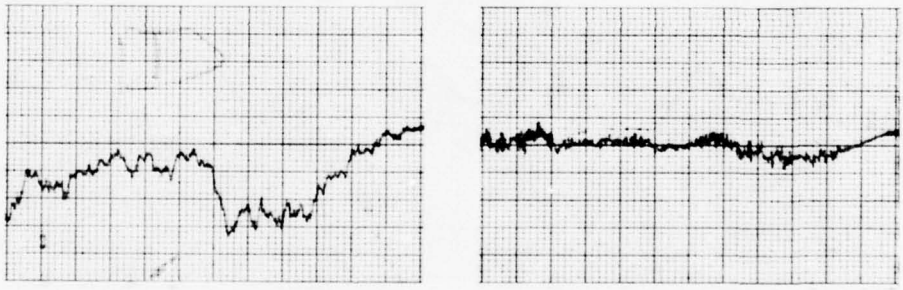
FM SPECTRUM



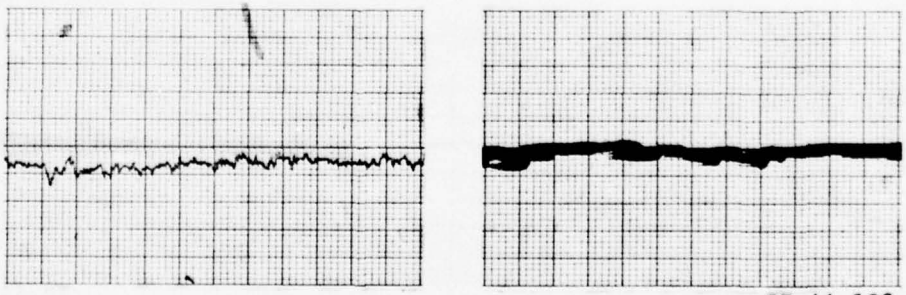
CDI

AGC

MARK 12



BENDIX



77-44-103

FIGURE 103. HOUSTON - HOBBY FIELD FRAME 1

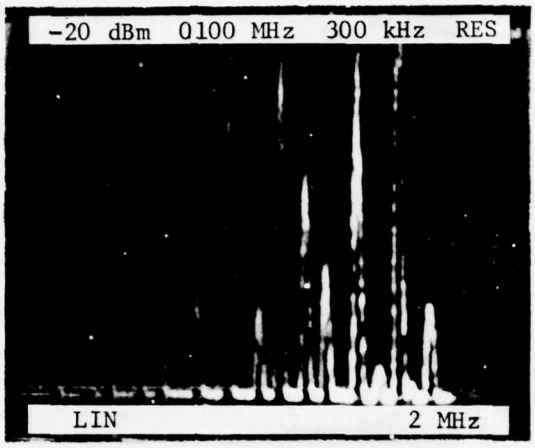
LOCATION - 2 nmi from middle marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

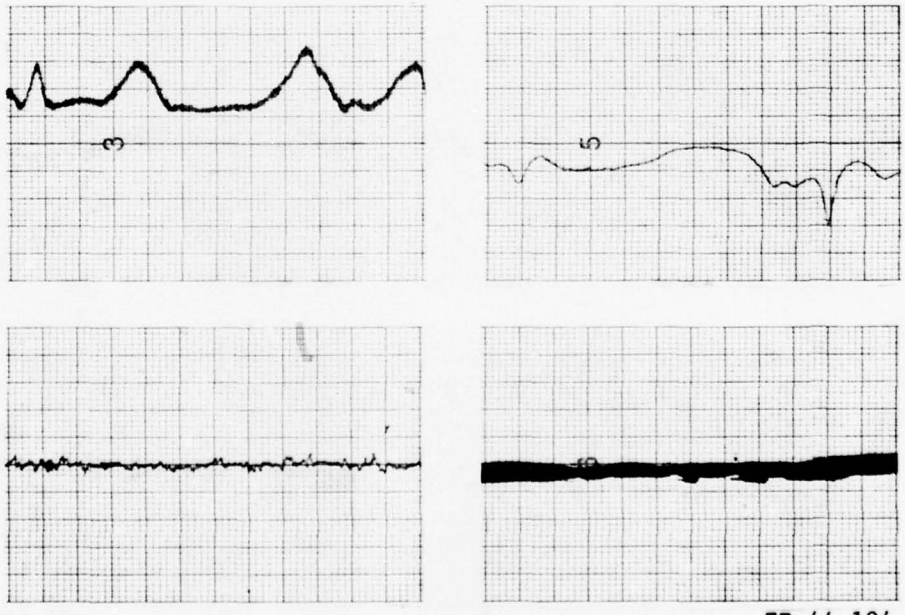
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-104

FIGURE 104. HOUSTON - HOBBY FIELD FRAME 2

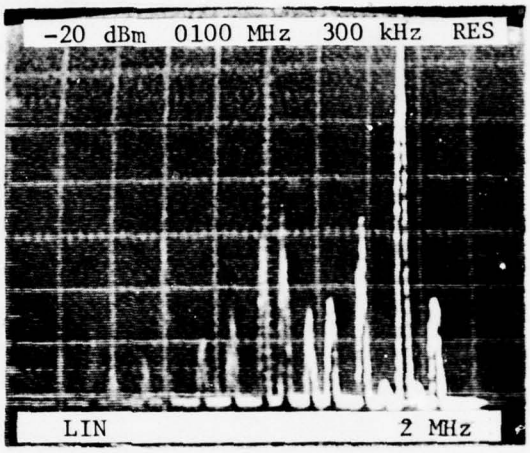
LOCATION - 5 nmi from outer marker

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

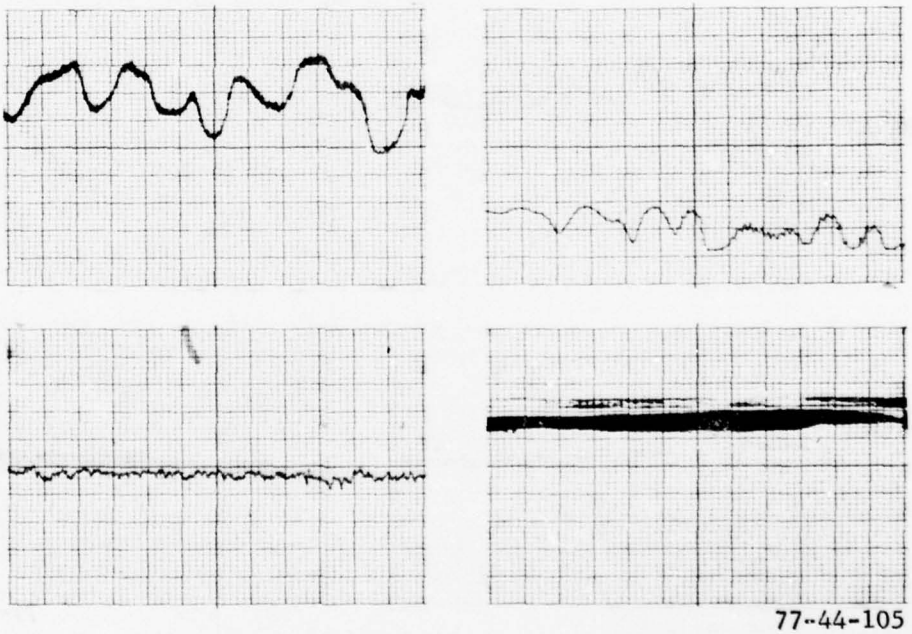
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-105

FIGURE 105. HOUSTON - HOBBY FIELD FRAME 3

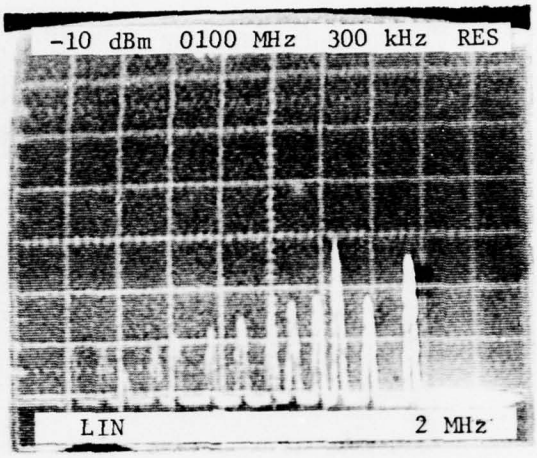
LOCATION - 1 nmi inside of outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

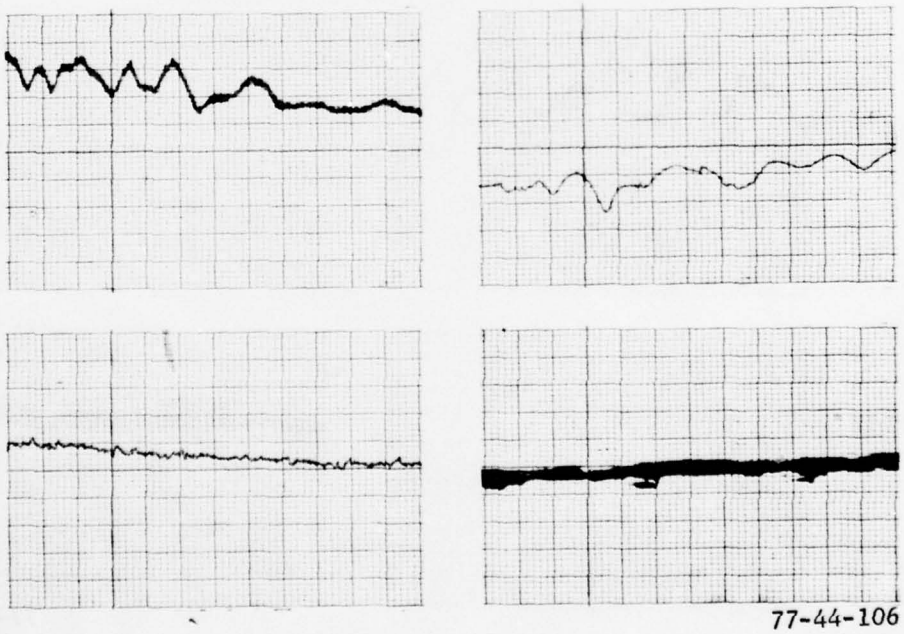


FIGURE 106. HOUSTON - HOBBY FIELD FRAME 4

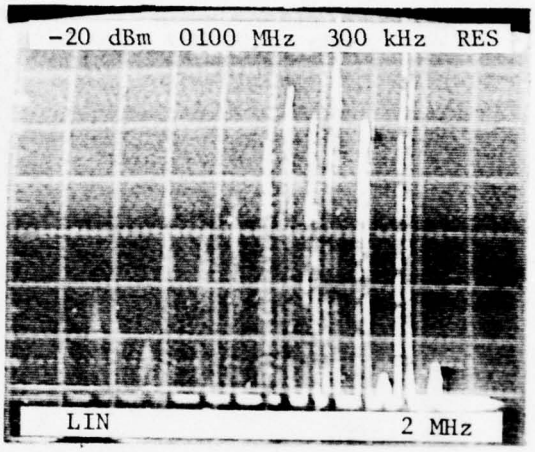
LOCATION - 182°R/17 nmi from Houston VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating sound

FM SPECTRUM



CDI AGC

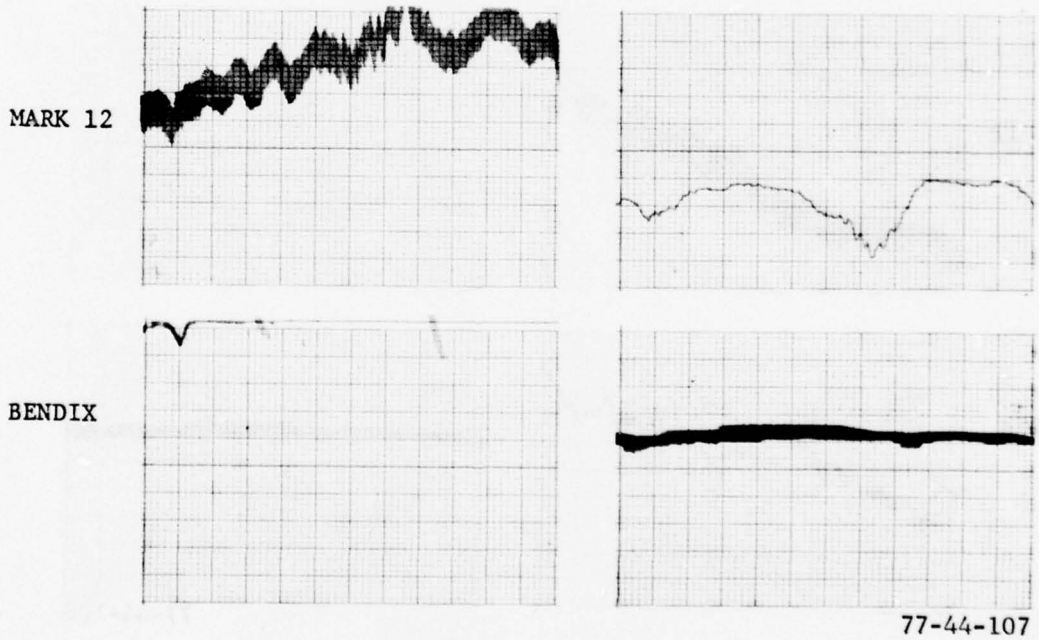


FIGURE 107. HOUSTON - HOBBY FIELD FRAME 5

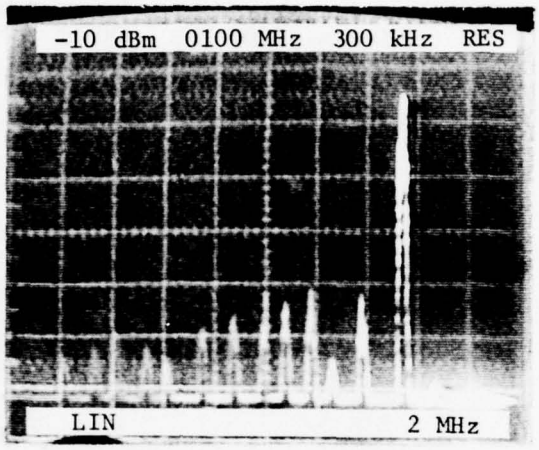
LOCATION - 182°R/15 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating sound

FM SPECTRUM



CDI AGC

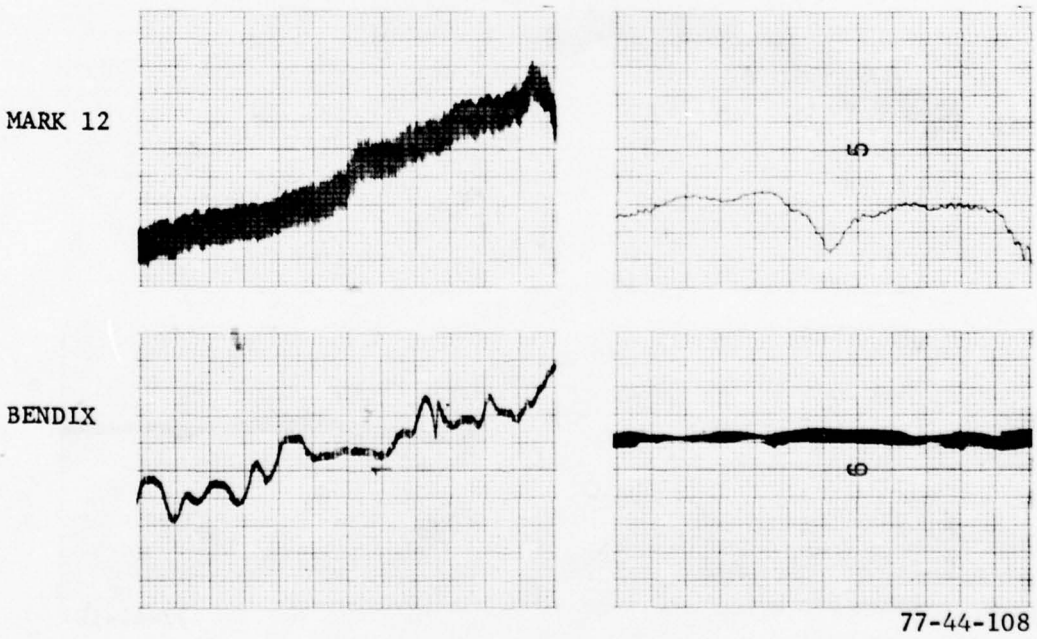


FIGURE 108. HOUSTON - HOBBY FIELD FRAME 6

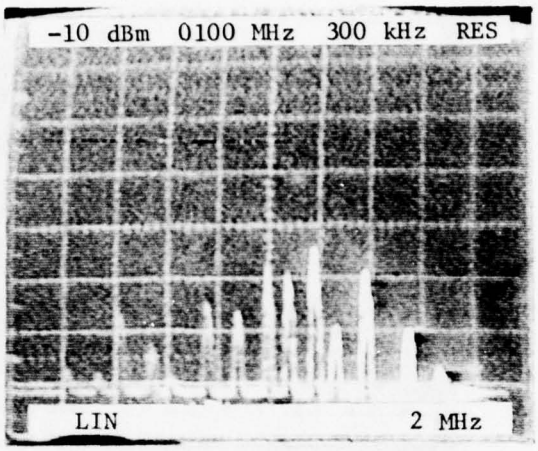
LOCATION - 160°R/7 nmi turning

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

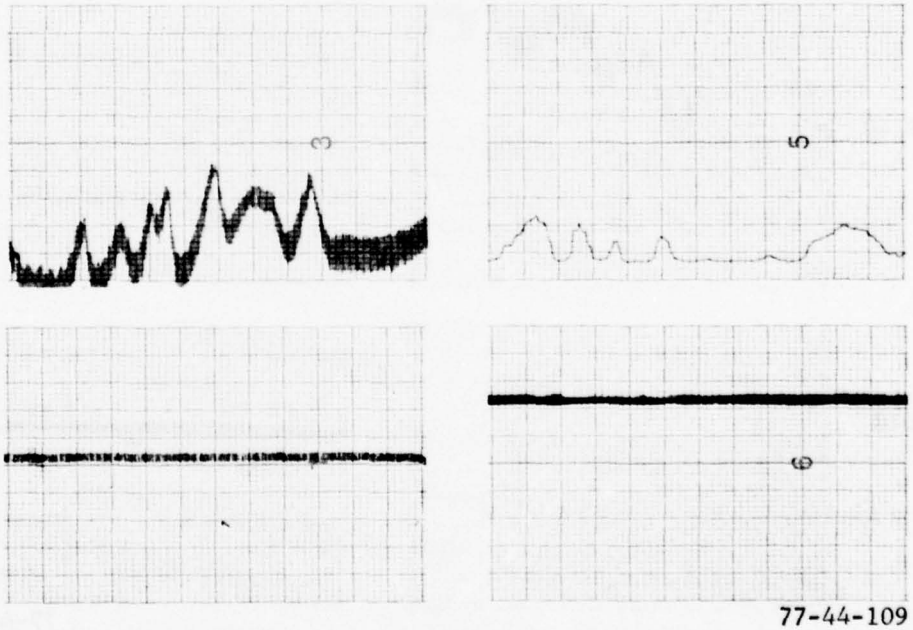
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-109

FIGURE 109. HOUSTON - HOBBY FIELD FRAME 7

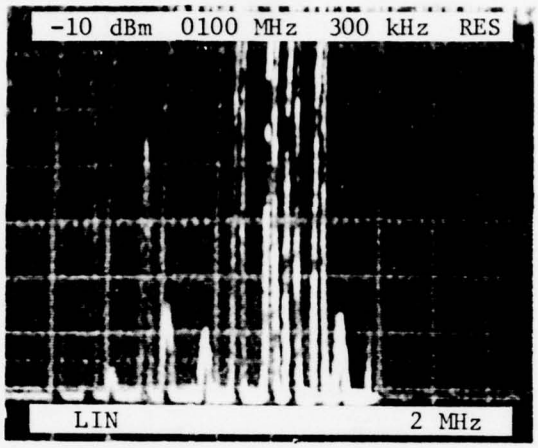
LOCATION - 184°R/16 nmi from VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

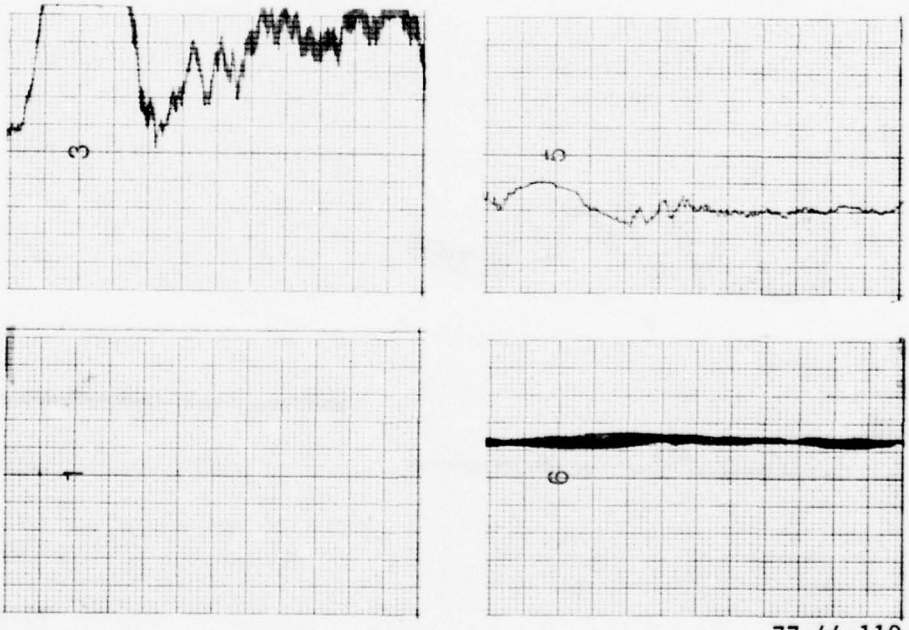
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-110

FIGURE 110. HOUSTON - HOBBY FIELD FRAME 8

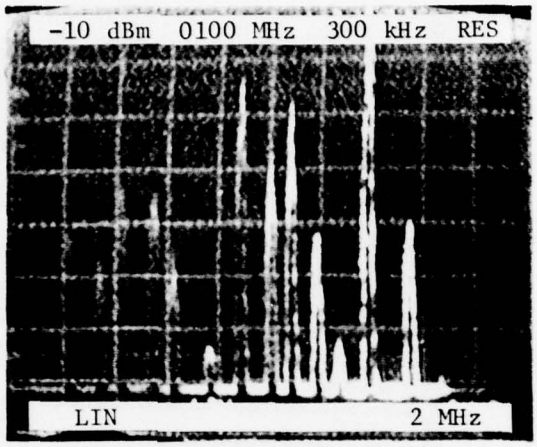
LOCATION - 170°R/12 nmi over ANTENNA #3

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

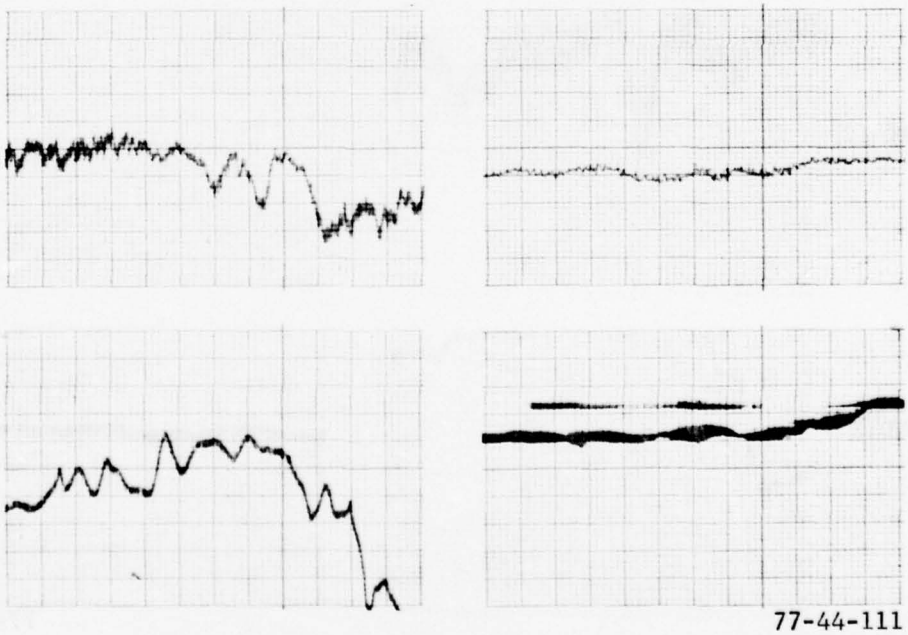
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-111

FIGURE 111. HOUSTON - HOBBY FIELD FRAME 9

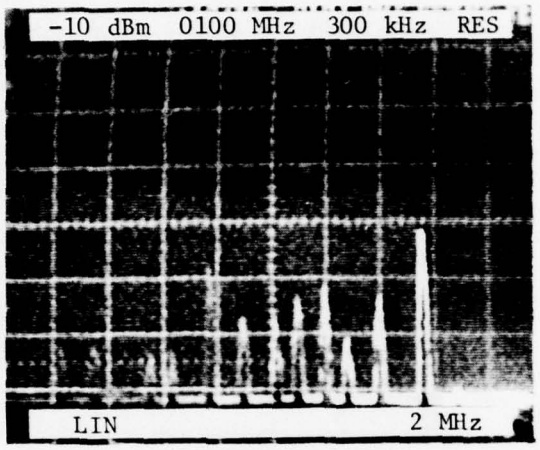
LOCATION - 170°R/13 nmi

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

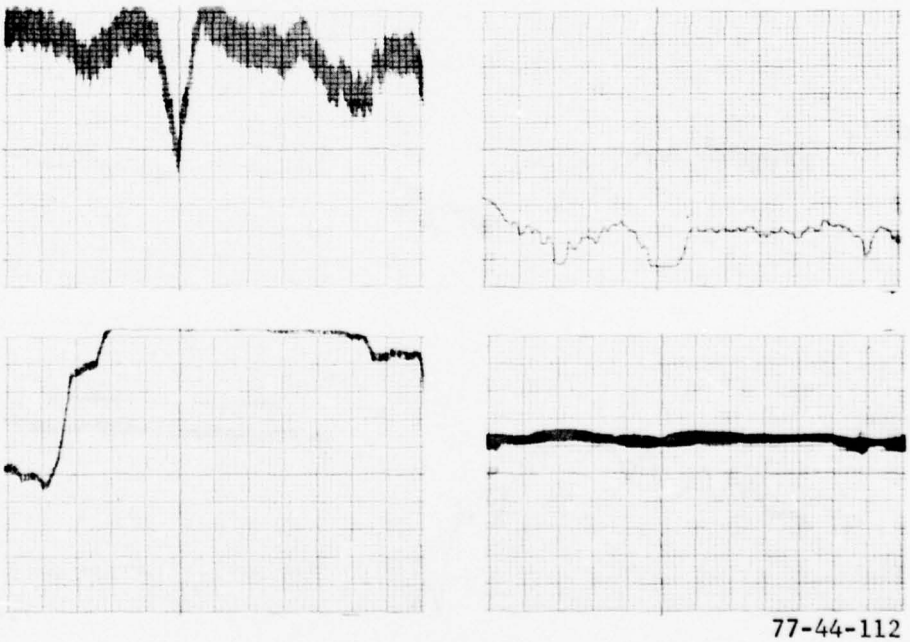
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-112

FIGURE 112. HOUSTON - HOBBY FIELD FRAME 10

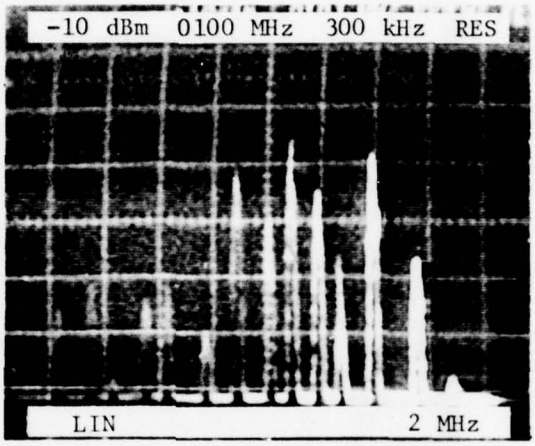
LOCATION - 180°R/12 nmi over ANTENNAS #3 and #1

AUDIO INTERFERENCES

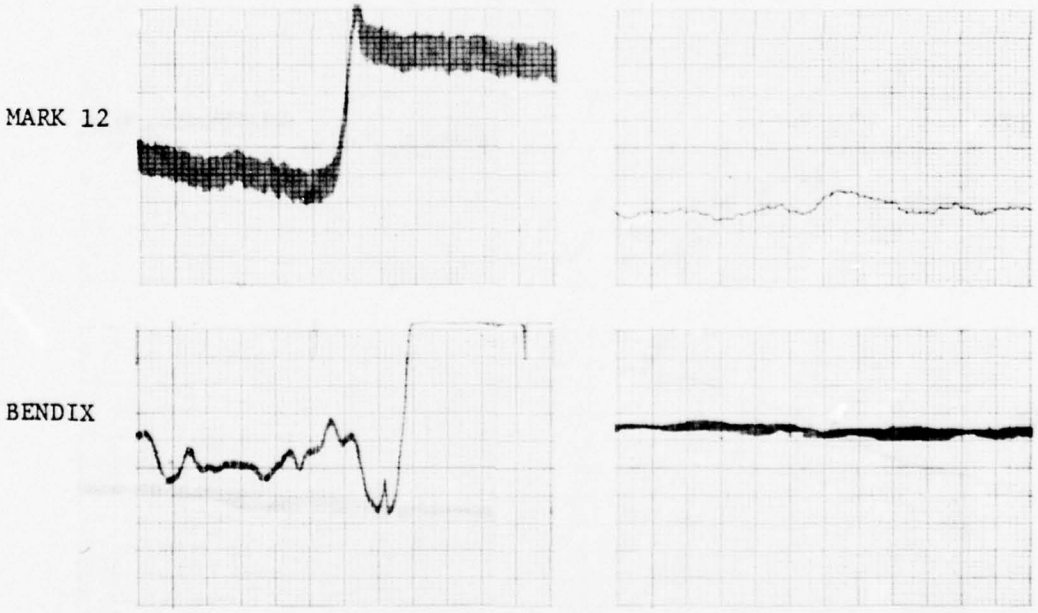
BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC



77-44-113

FIGURE 113. HOUSTON - HOBBY FIELD FRAME 11

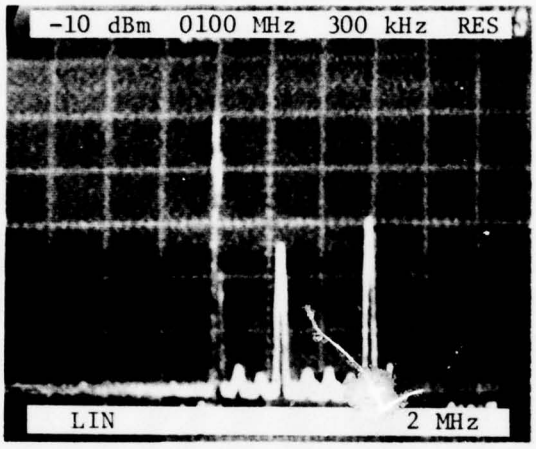
LOCATION - Back course, Rwy 31R, 3 nmi from threshold

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

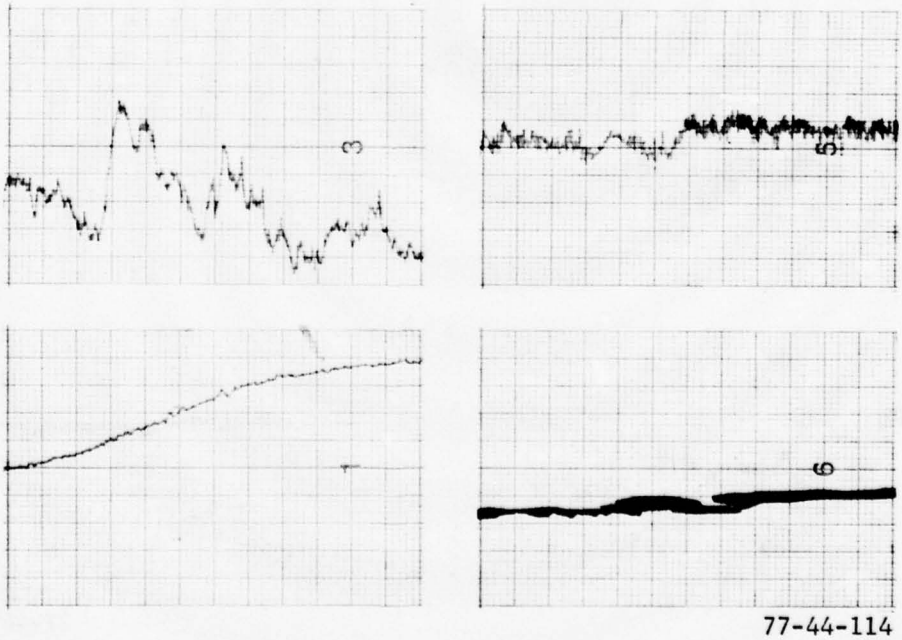
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-114

FIGURE 114. DALLAS - LOVE FIELD FRAME 1

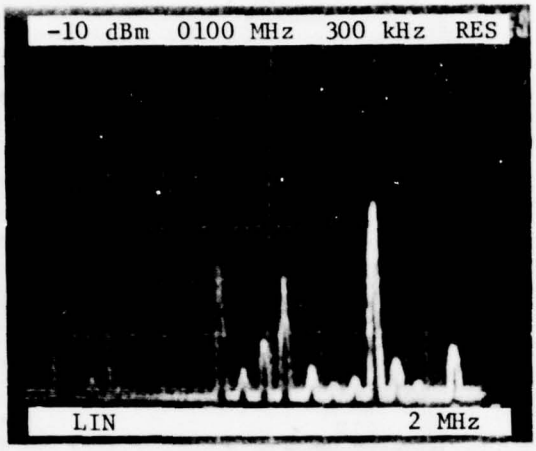
LOCATION - Back course, Rwy 31R, 3 nmi from threshold

AUDIO INTERFERENCES

BENDIX-None

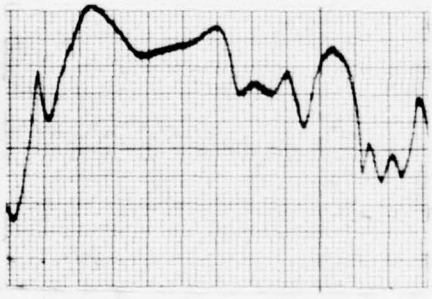
MARK 12-Motorboating Sound

FM SPECTRUM

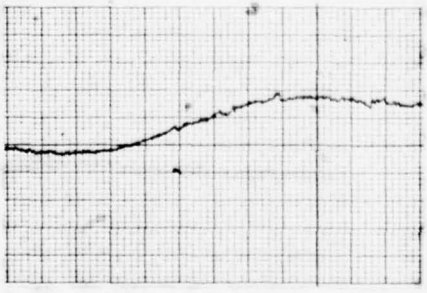


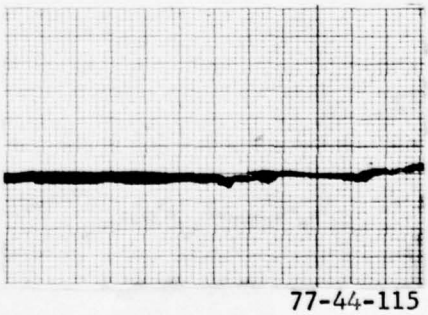
CDI AGC

MARK 12



BENDIX





77-44-115

FIGURE 115. DALLAS - LOVE FIELD FRAME 2

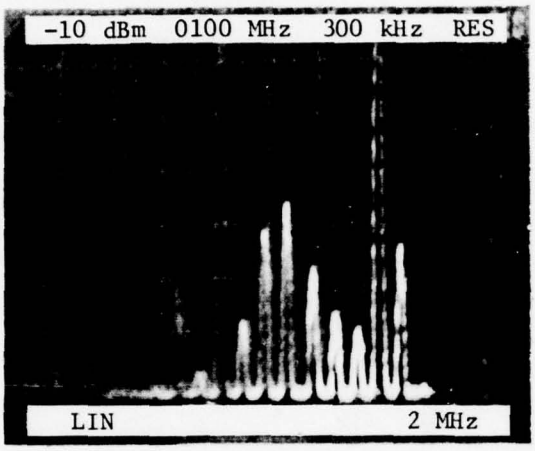
LOCATION - Rwy 31L, 1 nmi from middle marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

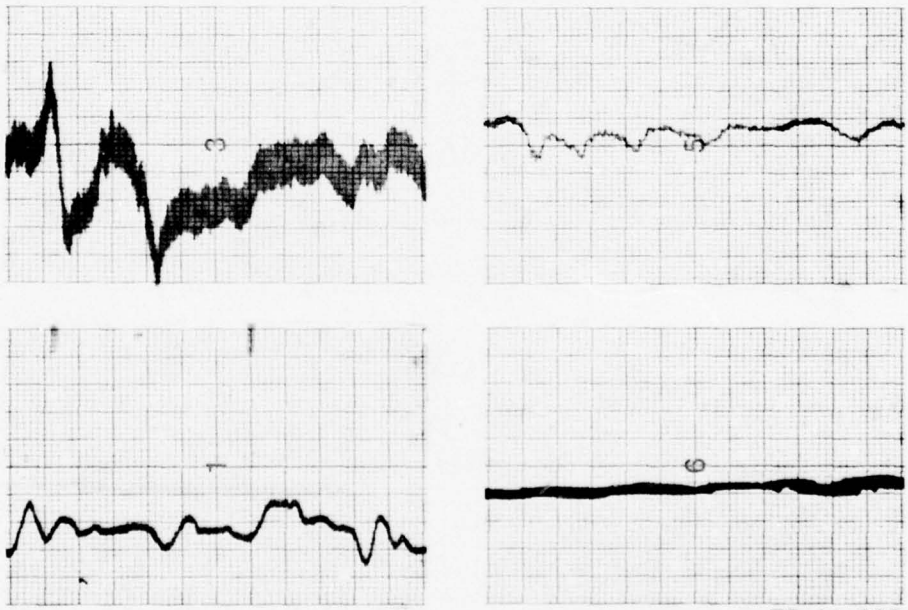
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-116

FIGURE 116. DALLAS - LOVE FIELD FRAME 3

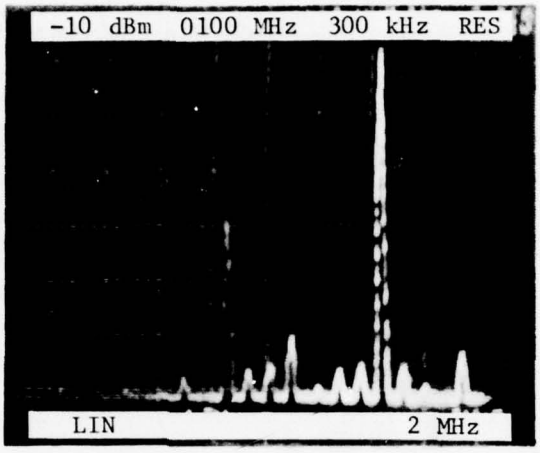
LOCATION - Between middle and outer markers

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

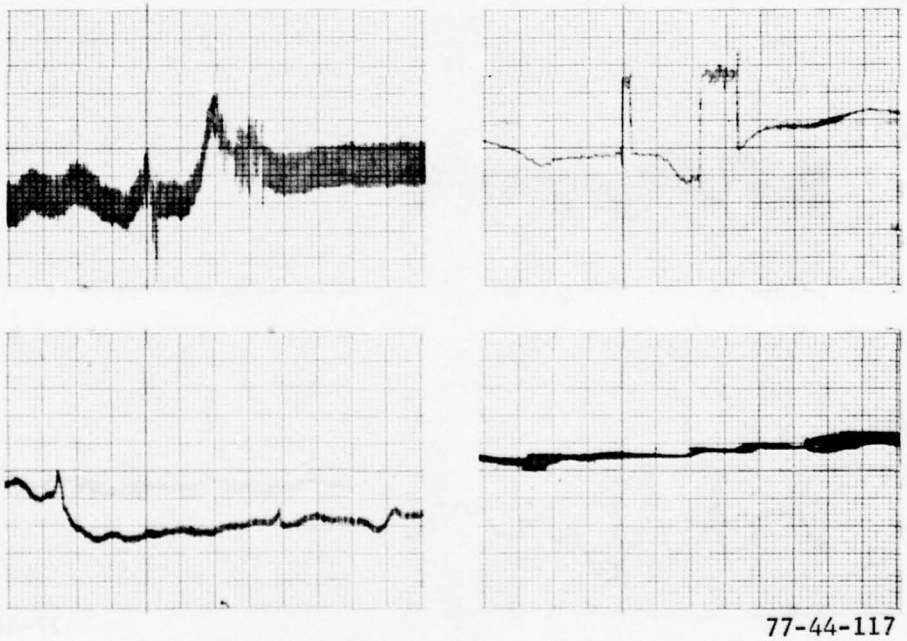
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-117

FIGURE 117. DALLAS - LOVE FIELD FRAME 4

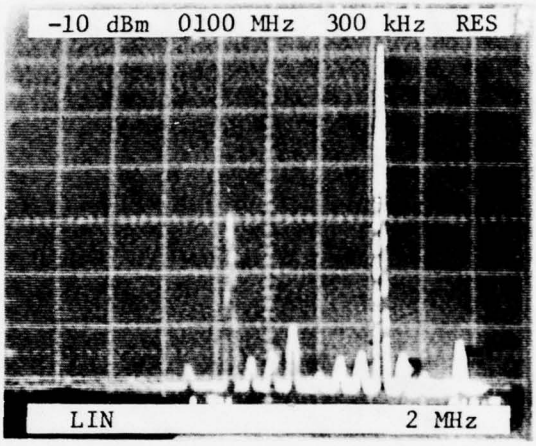
LOCATION - Between middle marker and threshold

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-118

FIGURE 118. DALLAS - LOVE FIELD FRAME 5

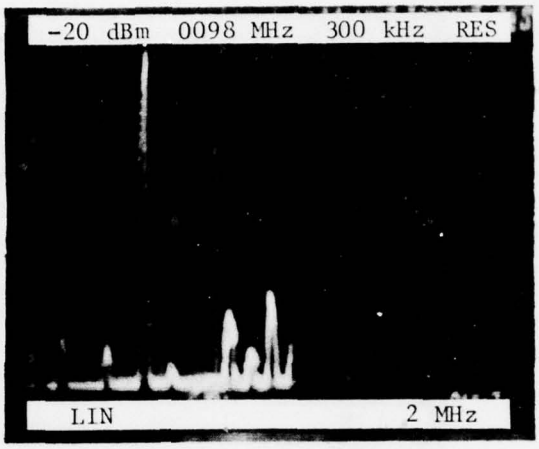
LOCATION -080°R/9 nmi from Greater Southwest (GSW) VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-119

FIGURE 119. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 1

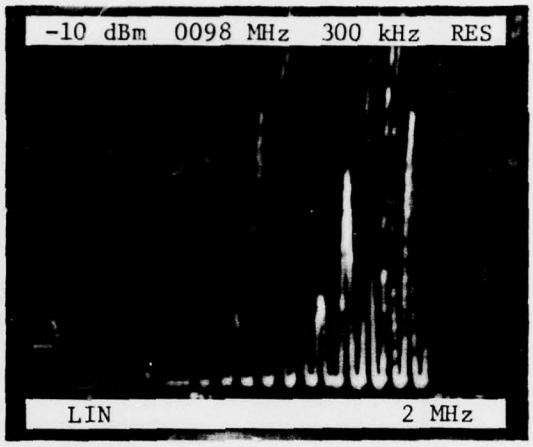
LOCATION - 080°R/9 nmi from Greater Southwest (GSW) turning

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

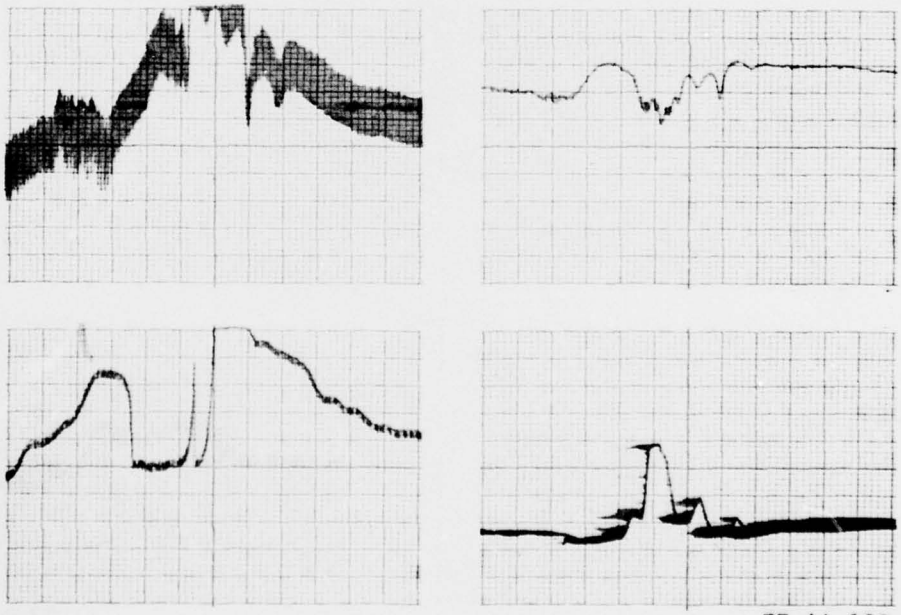
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-120

FIGURE 120. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 2

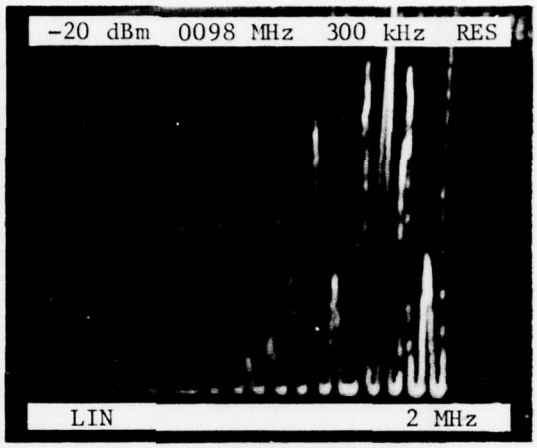
LOCATION - 260°R/14 nmi from GSW VORTAC

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

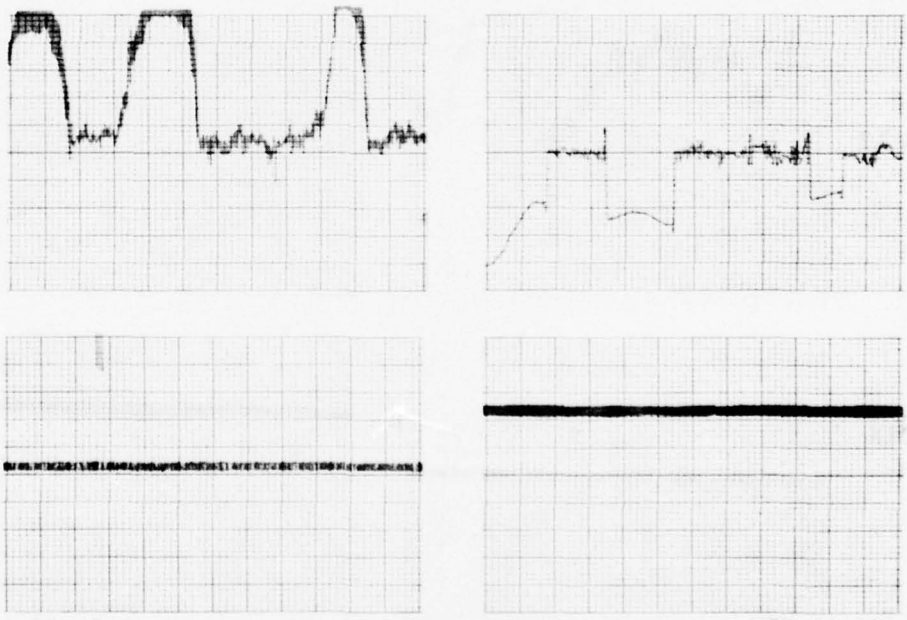
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-121

FIGURE 121. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS **FRAME 3**

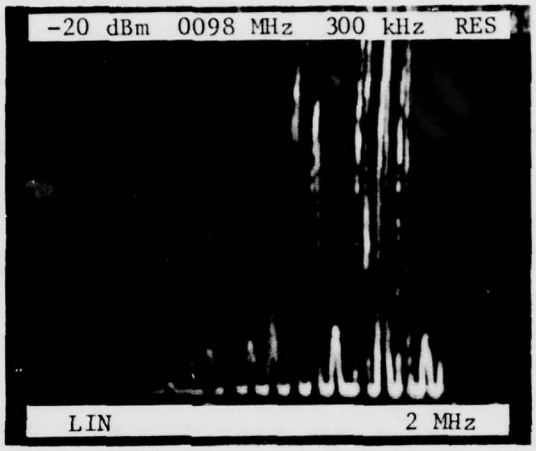
LOCATION - 250°/12 nmi from GSW, over ANTENNA #11

AUDIO INTERFERENCES

BENDIX- None

MARK 12- High Background Noise

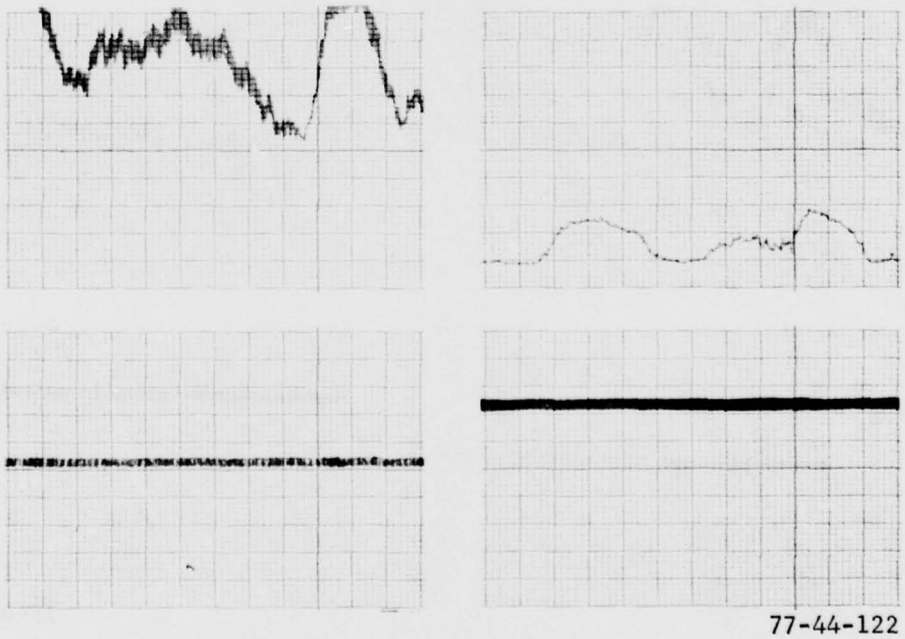
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-122

FIGURE 122. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 4

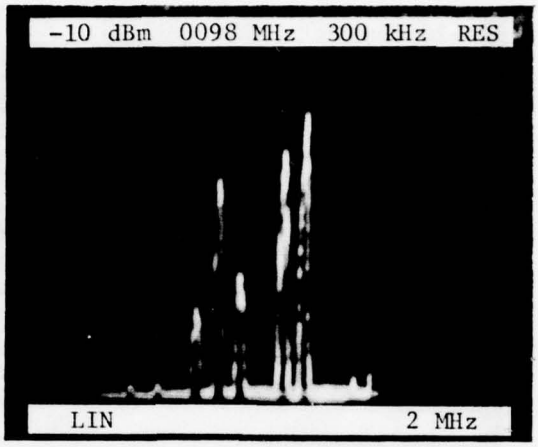
LOCATION - 230°R/12 nmi from GSW, over ANTENNA #8

AUDIO INTERFERENCES

BENDIX- None

MARK 12-High Background Noise

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-123

FIGURE 123. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 5

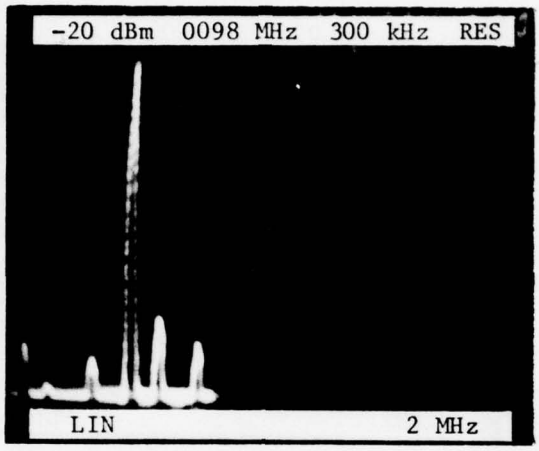
LOCATION - 210°R/12 nmi from GSW, over ANTENNA #8

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Noise and Motorboating

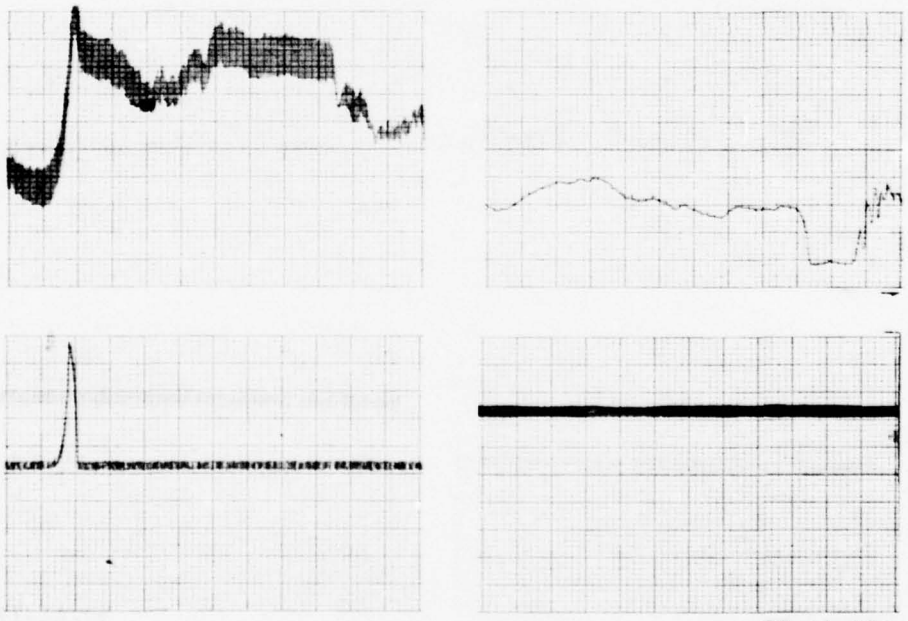
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-124

FIGURE 124. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 6

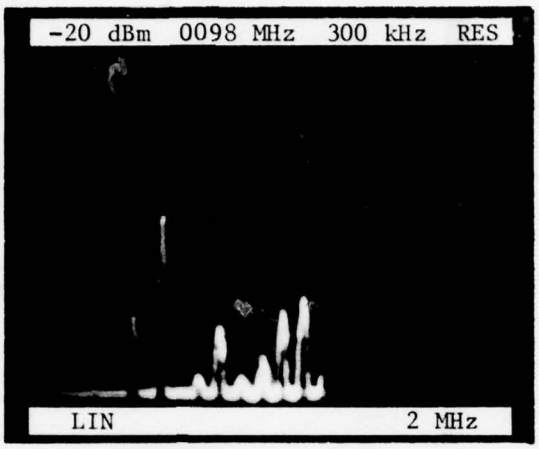
LOCATION - 175°R/15 nmi GSW

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-125

FIGURE 125. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 7

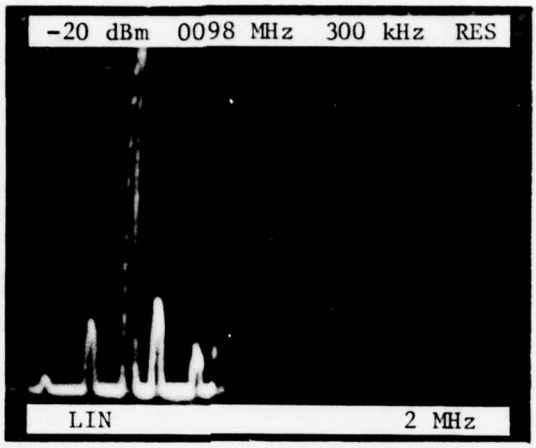
LOCATION - 160°R/18 nmi from GSW turning, over ANTENNA #2

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

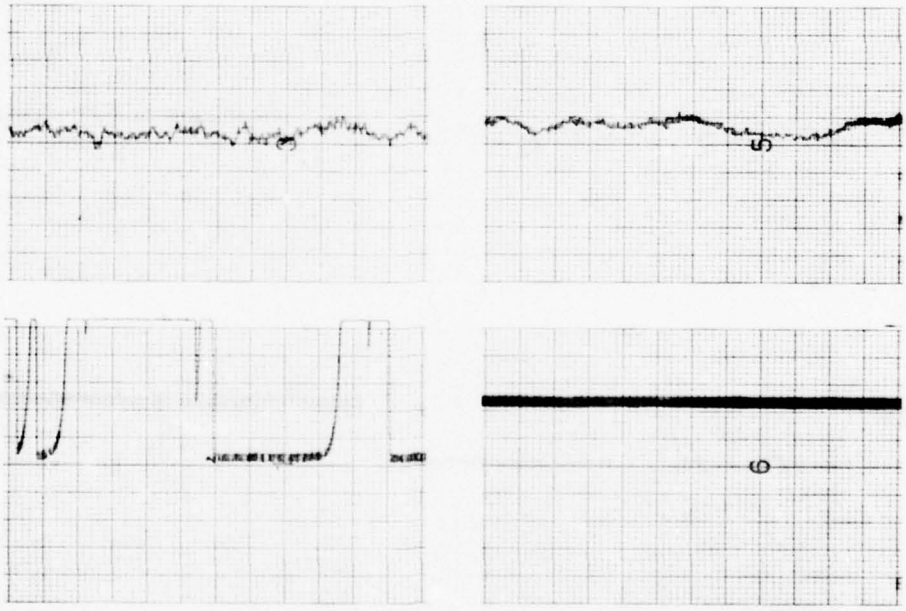
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-126

FIGURE 126. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 8

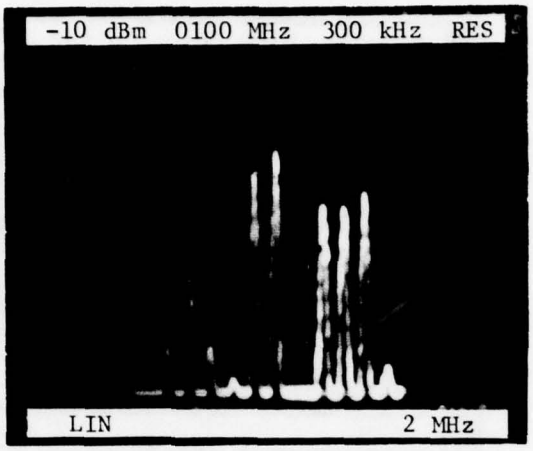
LOCATION - 135°R/15 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-High Background Noise

FM SPECTRUM



CDI AGC

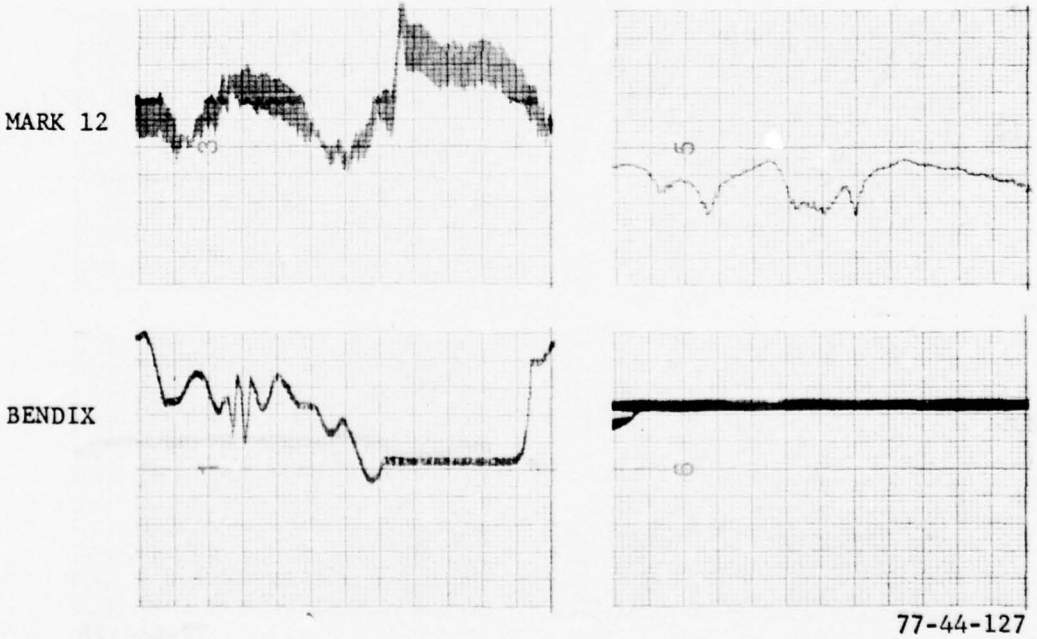


FIGURE 127. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 9

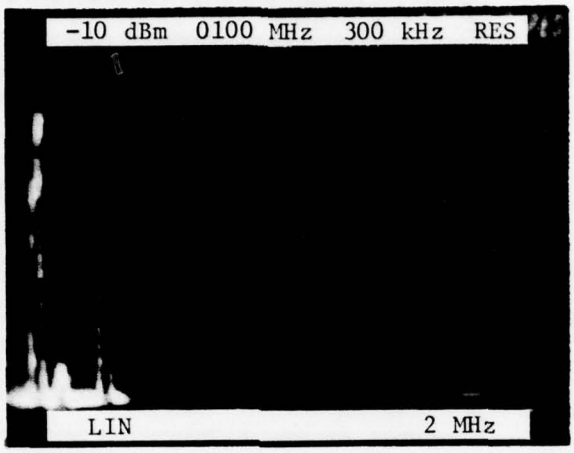
LOCATION - 110°R/15 nmi from GSW, over ANTENNA #6

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

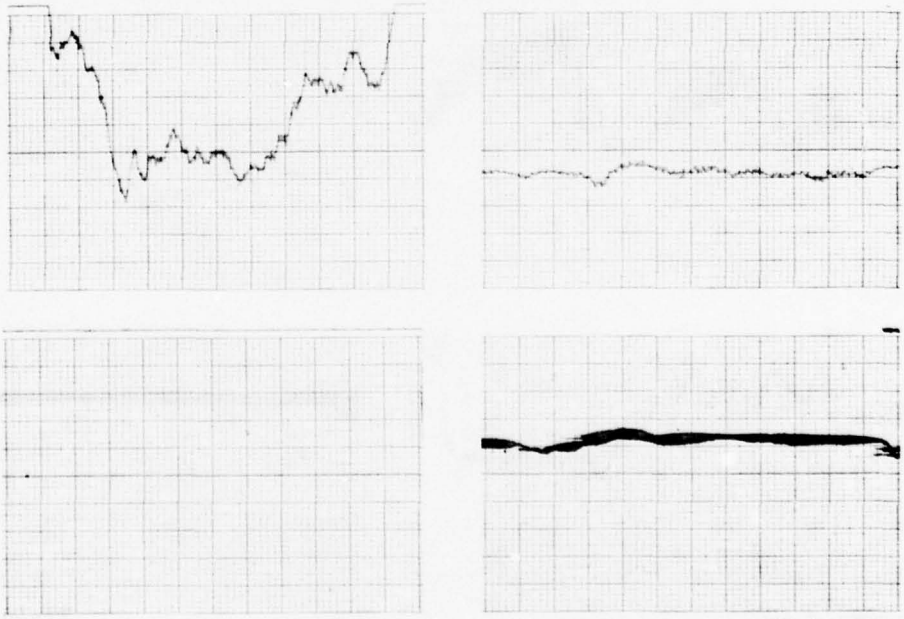
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-128

FIGURE 128. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 10

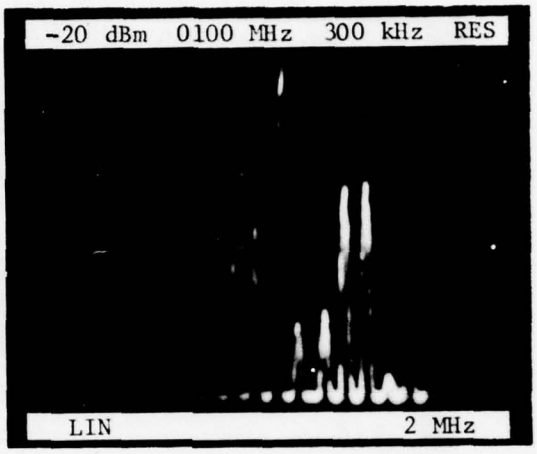
LOCATION - 135°R/16 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-High Background Noise

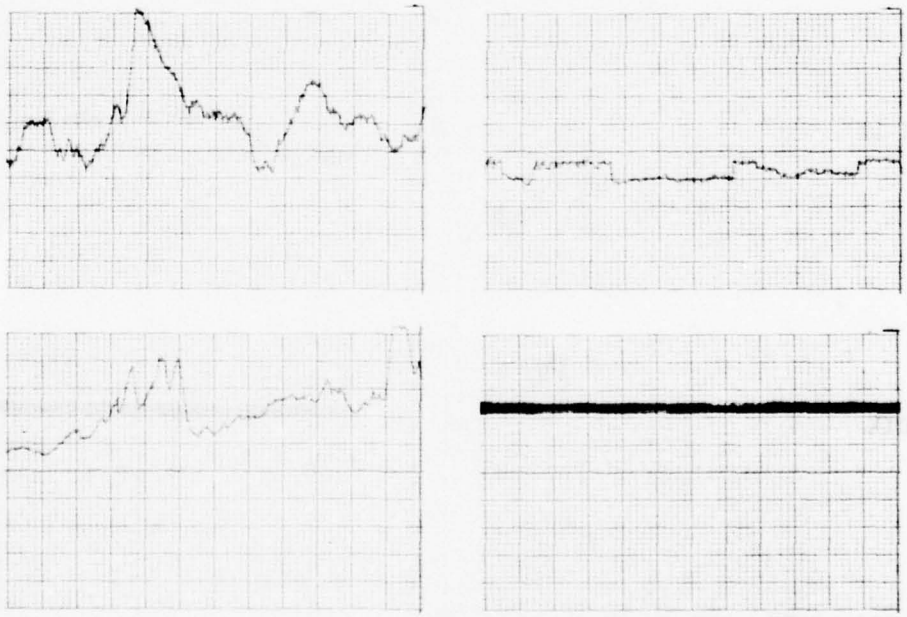
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-129

FIGURE 129. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 11

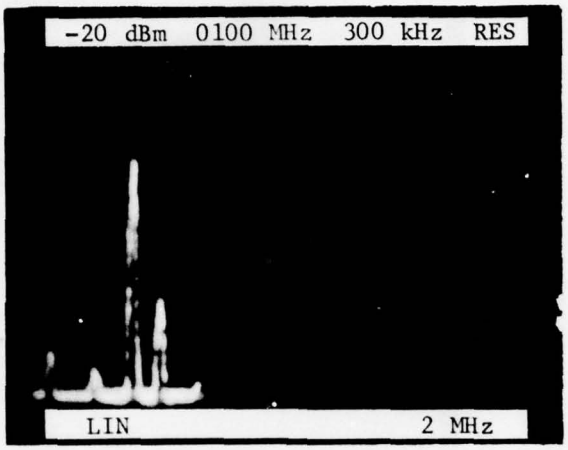
LOCATION - 155°R/18 nmi from GSW, over ANTENNA #2

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

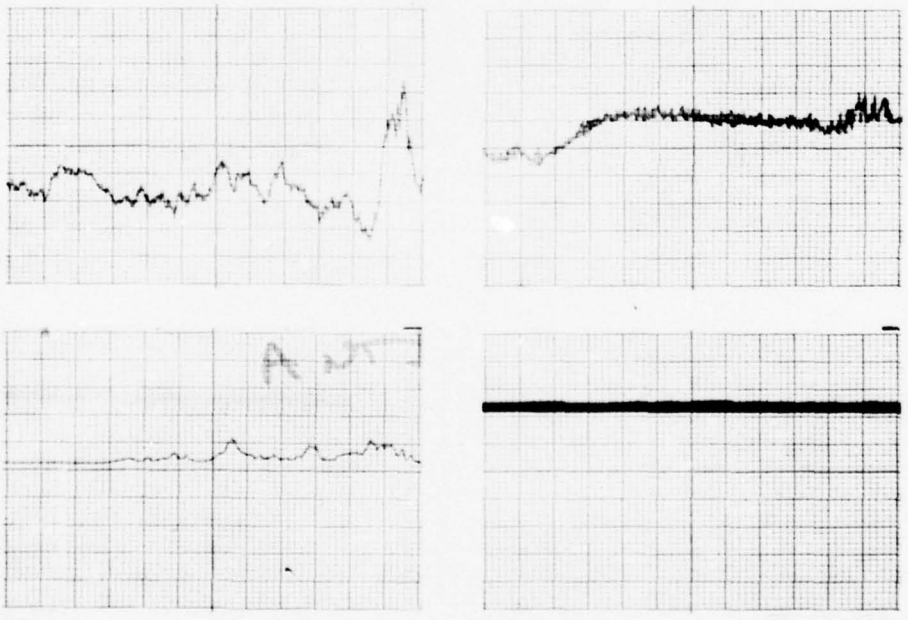
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-130

FIGURE 130. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 12

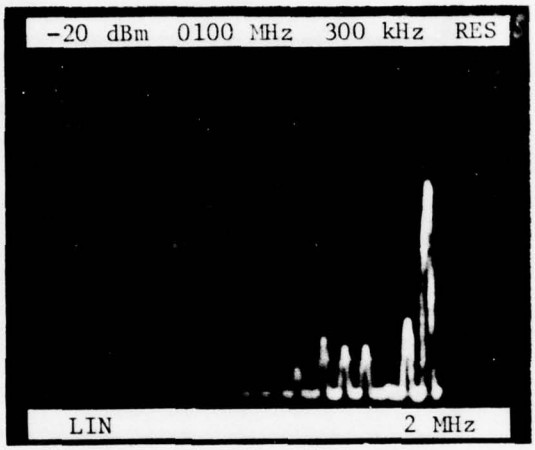
LOCATION - 170°R/16 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

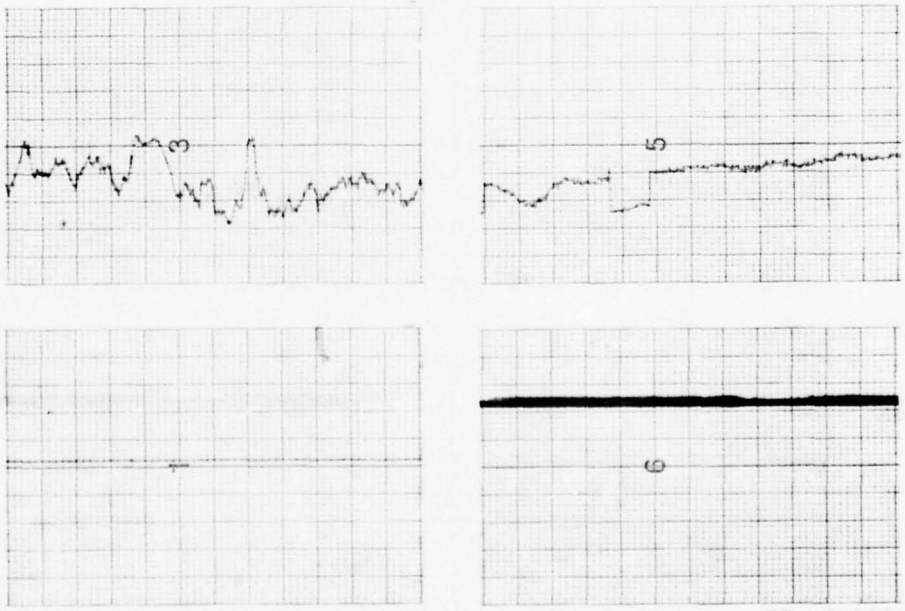
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-131

FIGURE 131. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 13

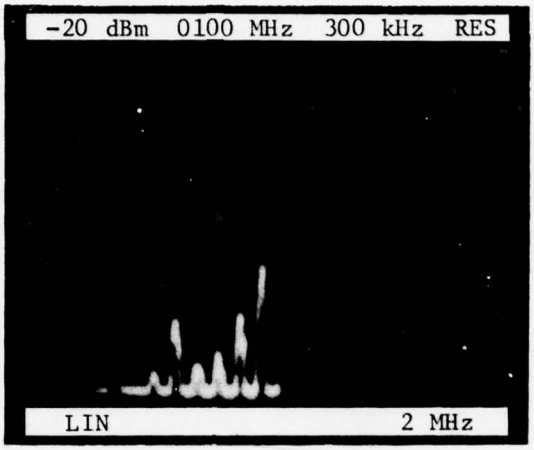
LOCATION - 185°R/14 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM



CDI AGC

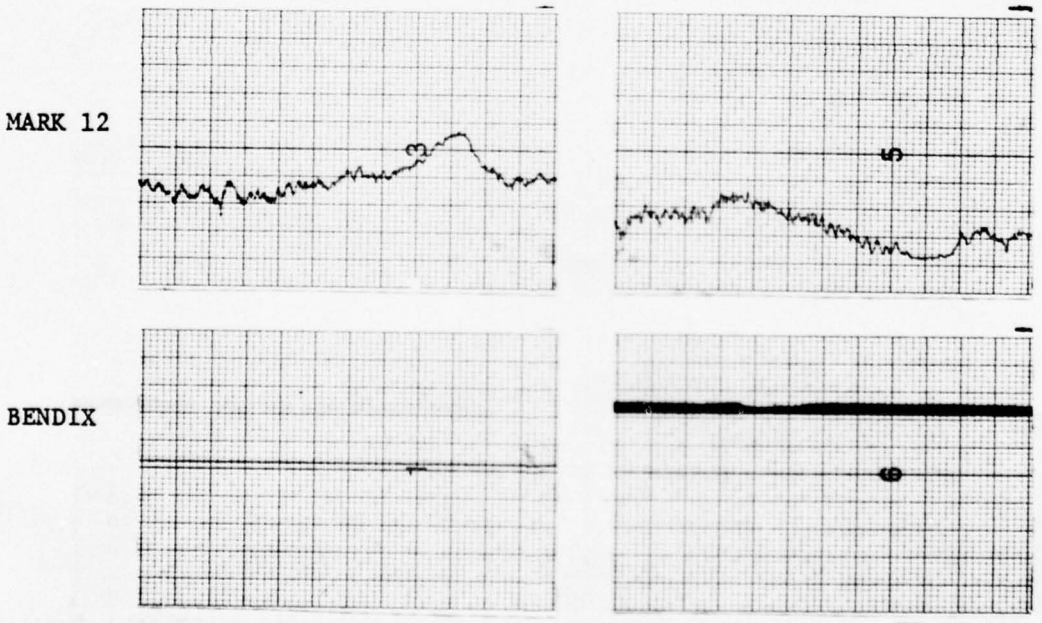


FIGURE 132. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 14

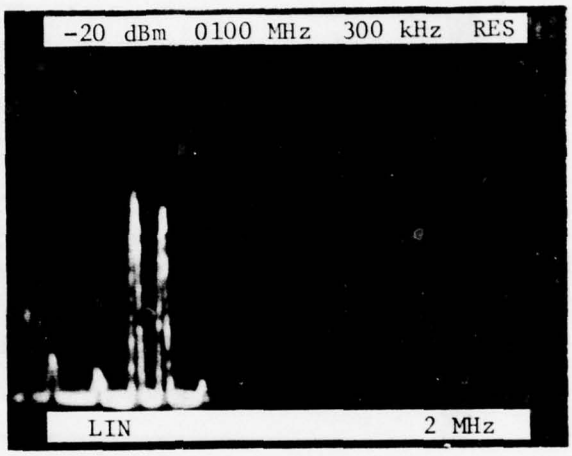
LOCATION - 200°R/14 nmi from GSW, over ANTENNAS #4 and #10

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM



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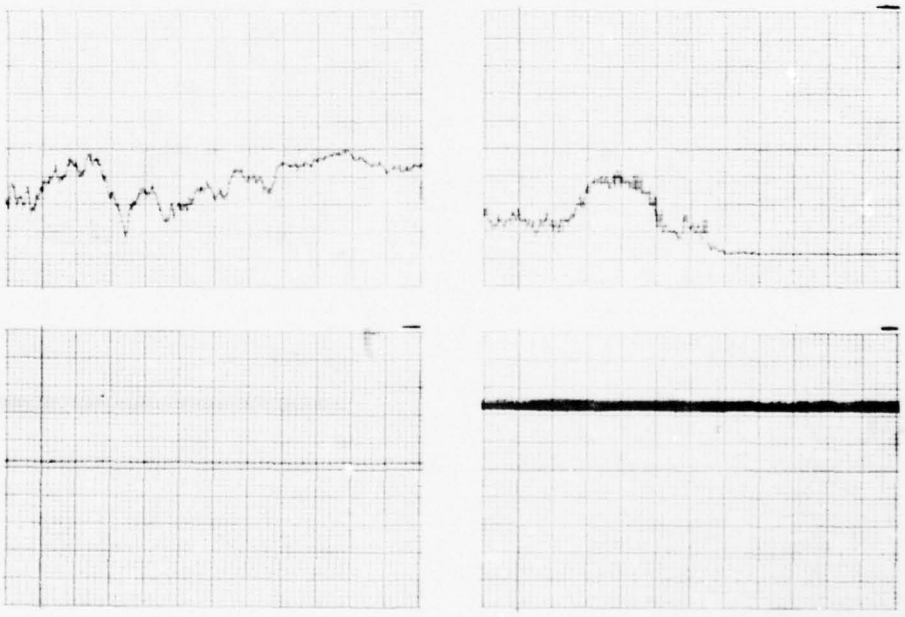
MARK 12

BENDIX



77-44-133

FIGURE 133. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 15

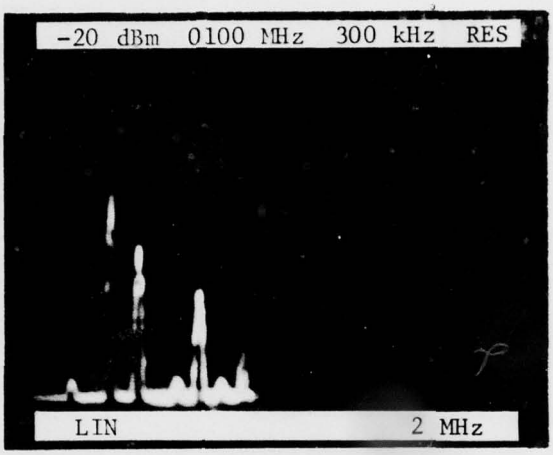
LOCATION - 210°R/14 nmi from GSW, over ANTENNAS #8 and #10

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

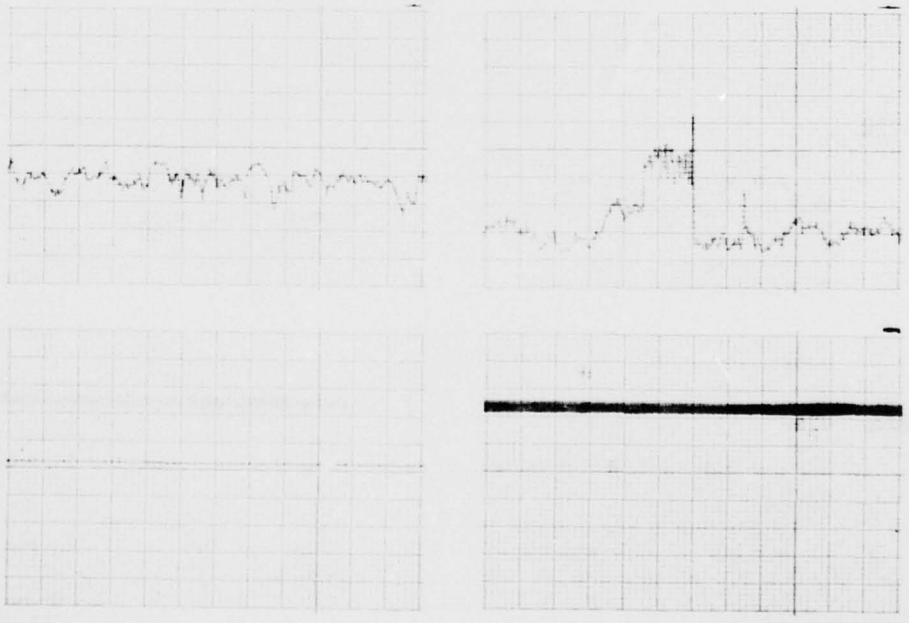
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-134

FIGURE 134. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 16

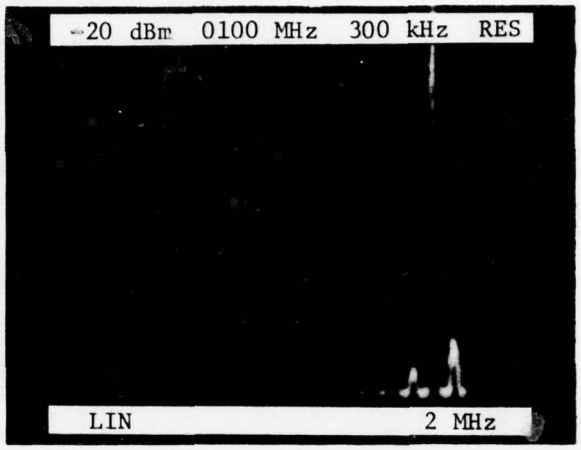
LOCATION - 165°R/15 nmi from GSW, over ANTENNAS #1, #4, and #9

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

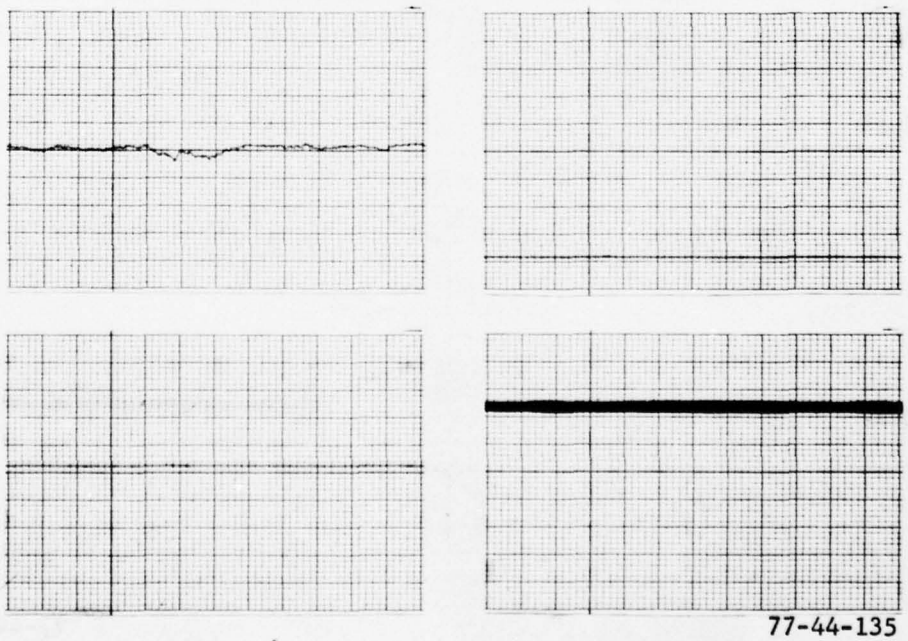


FIGURE 135. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 17

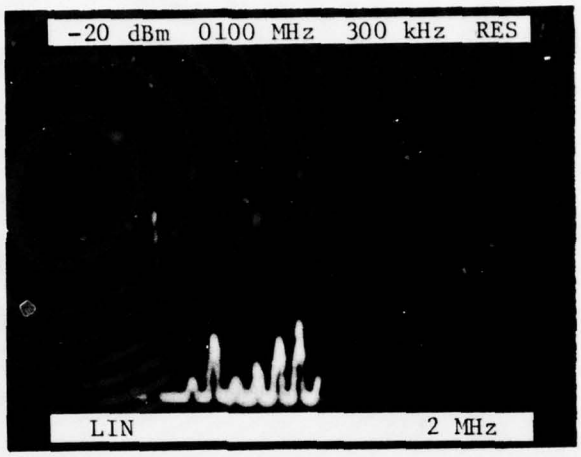
LOCATION - 125°R/15 nmi from GSW

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-136

FIGURE 136. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 18

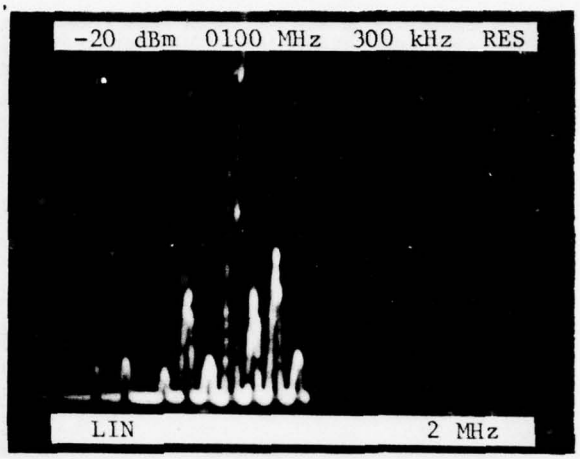
LOCATION - 110°R/15 nmi from GSW, over ANTENNA #6

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Motorboating Sound

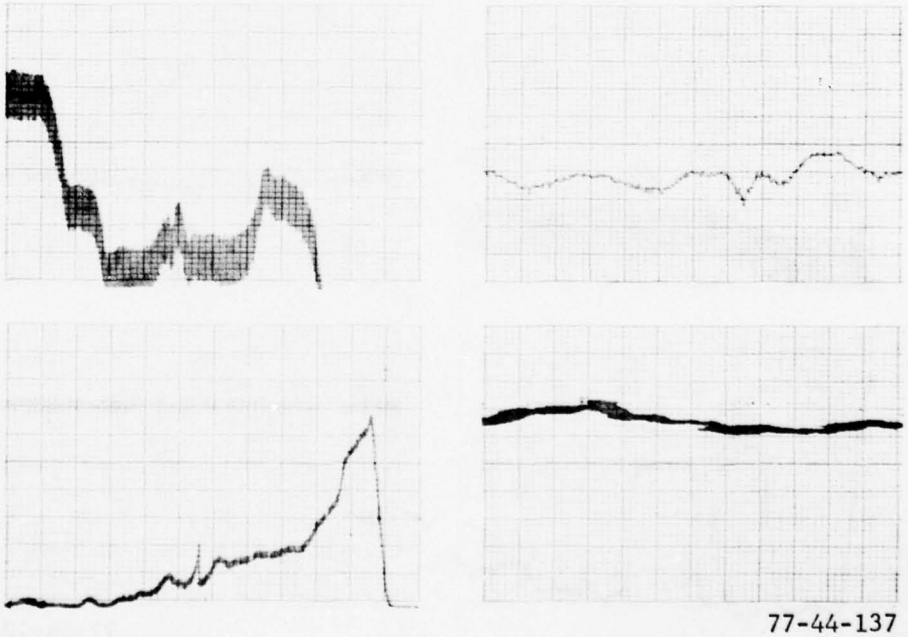
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-137

FIGURE 137. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 19

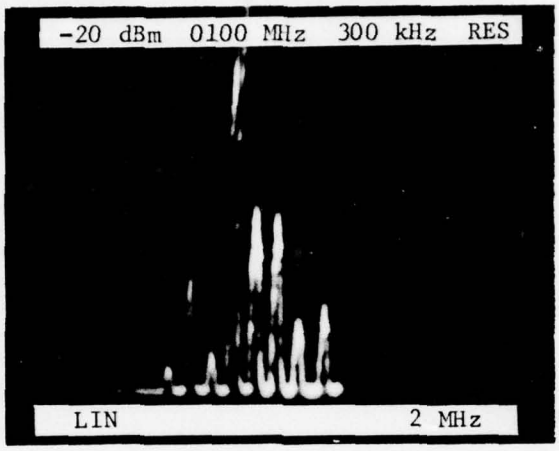
LOCATION - 120°R/16 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-138

FIGURE 138. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 20

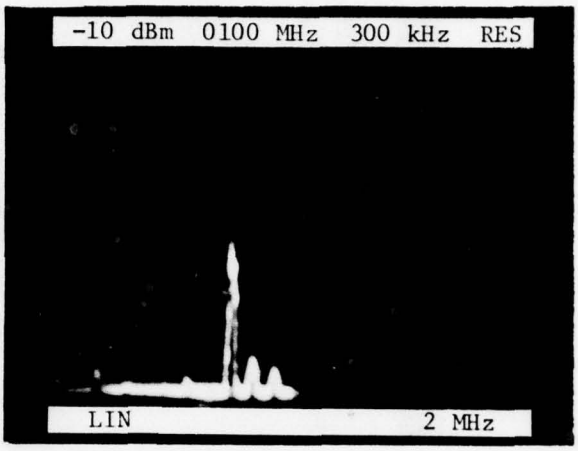
LOCATION - 140°R/17 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

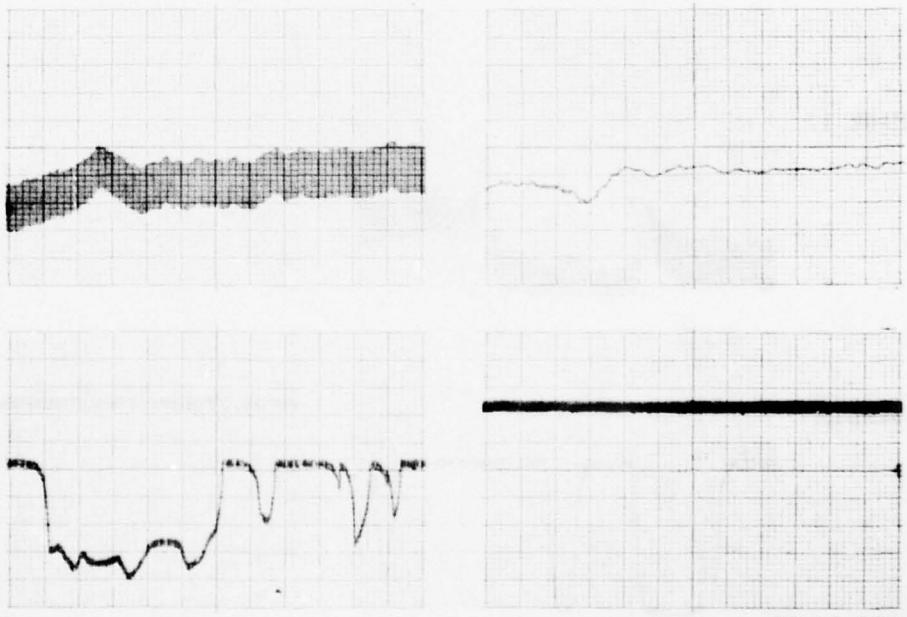
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-139

FIGURE 139. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 21

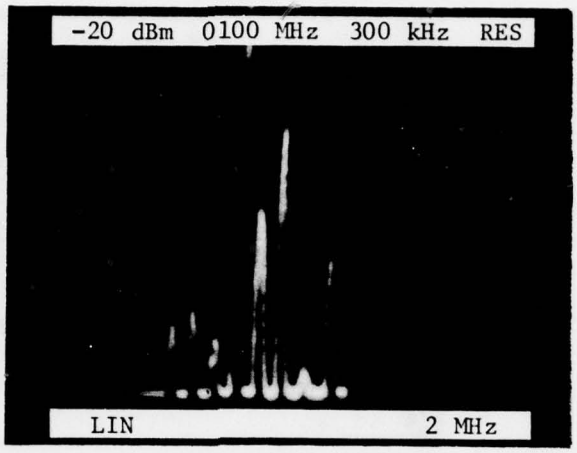
LOCATION - 150°R/17 nmi from GSW, over ANTENNA #2

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM



CDI AGC

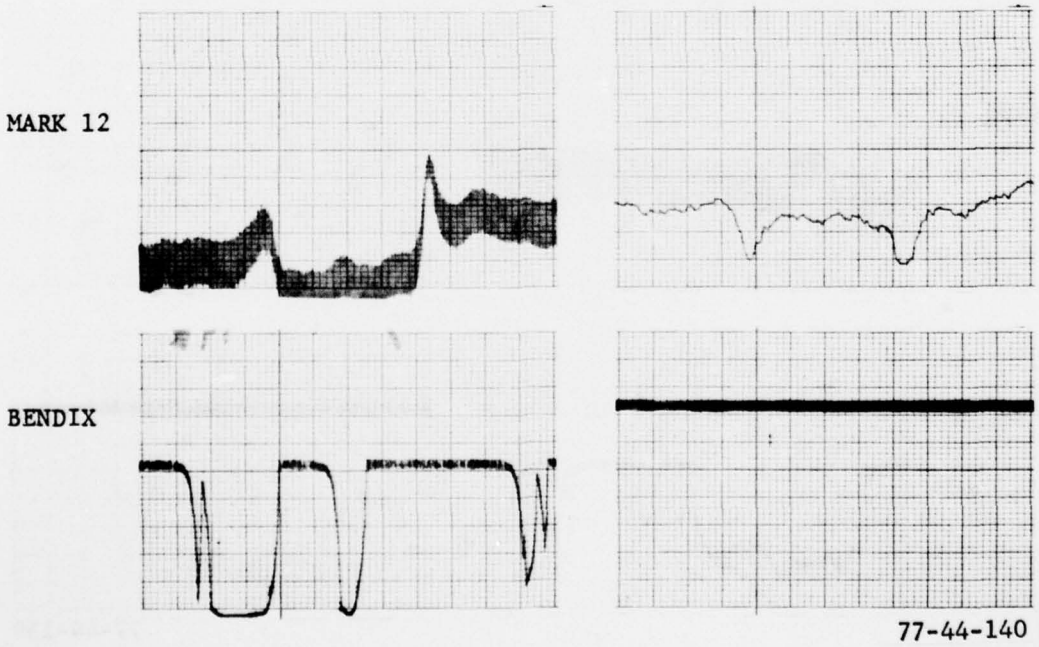


FIGURE 140. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 22

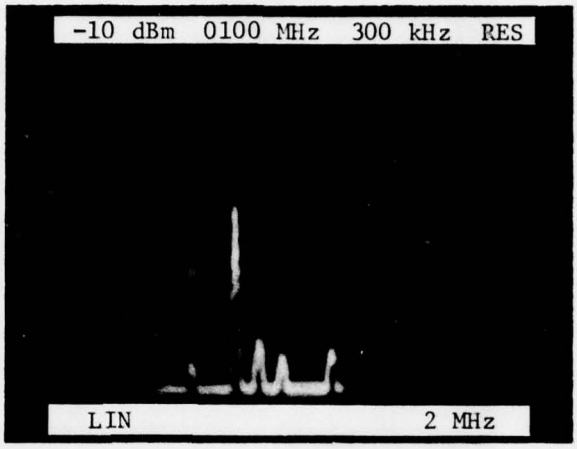
LOCATION - 170°R/16 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM



CDI AGC

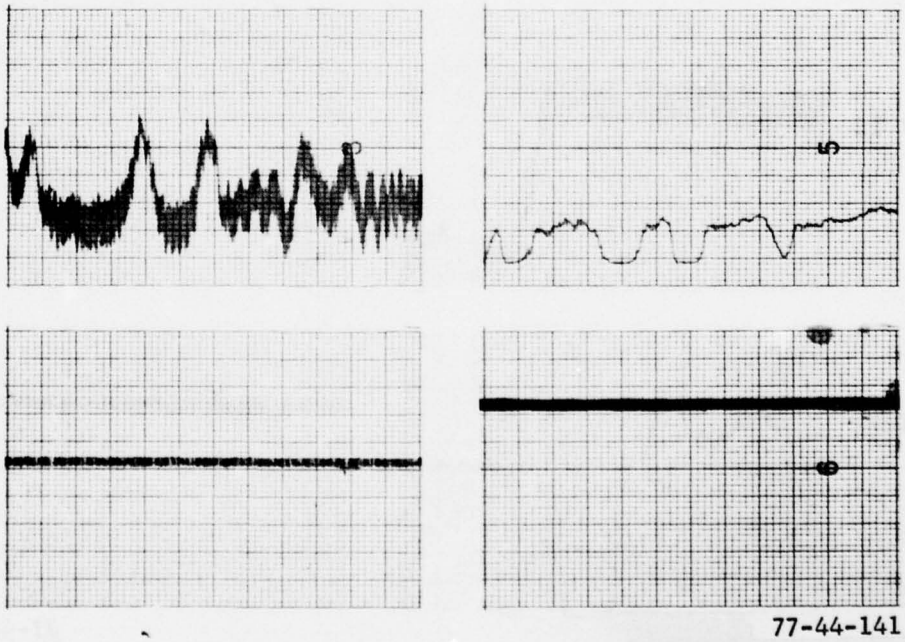


FIGURE 141. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 23

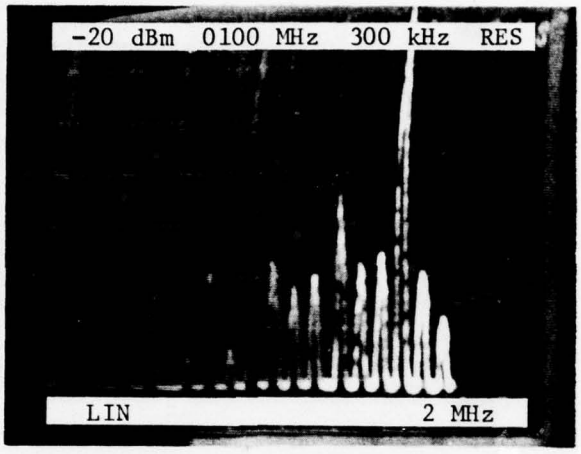
LOCATION - 180°R/15 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

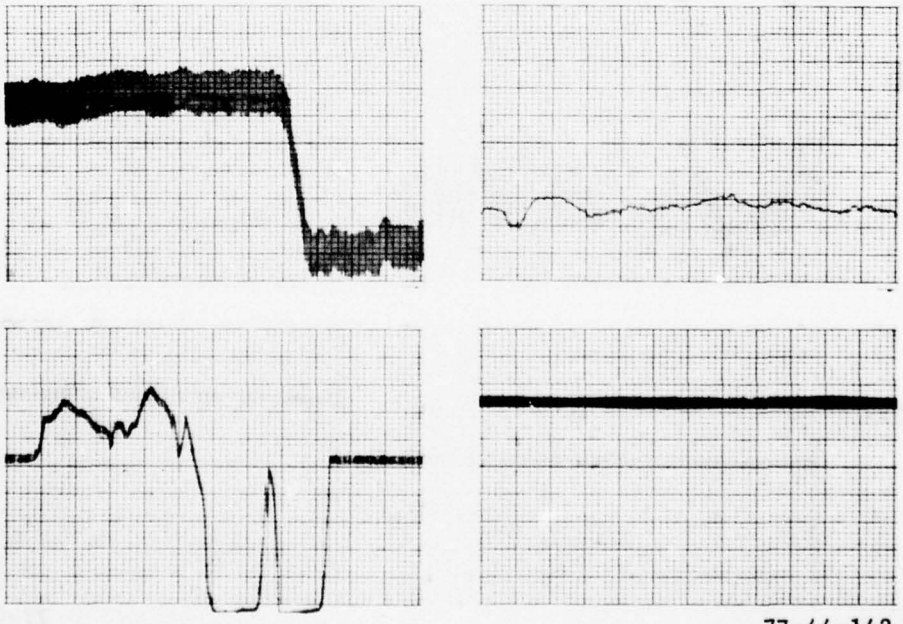
FM SPECTRUM



CDI AGC

MARK 12

BENDIX



77-44-142

FIGURE 142. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 24

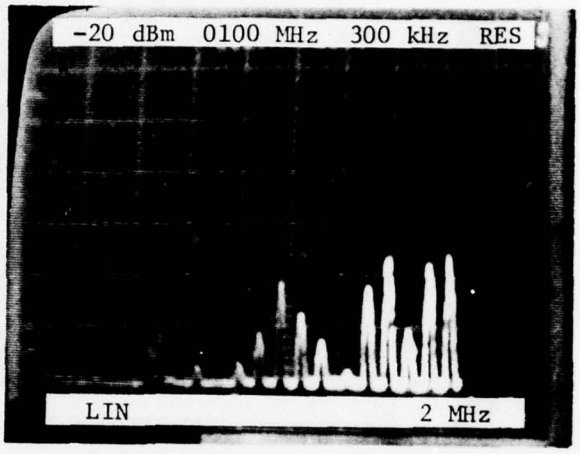
LOCATION - 230°R/14 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM



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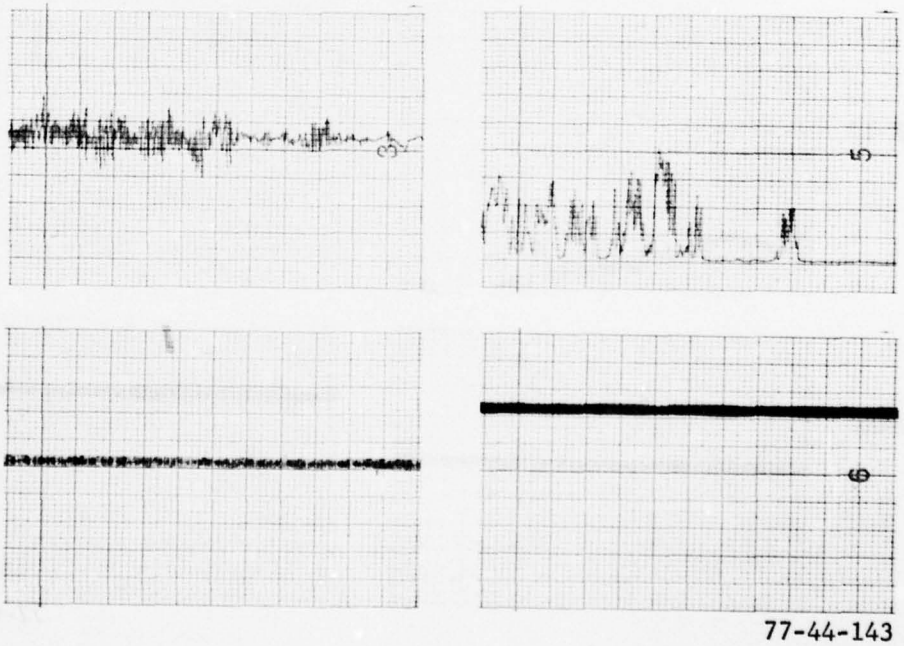
MARK 12

BENDIX



77-44-143

FIGURE 143. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 25

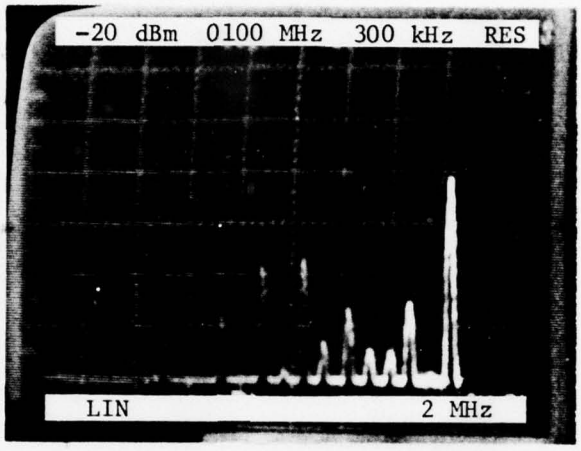
LOCATION - 160°R/17 nmi, over ANTENNAS #2 and #3

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM



CDI AGC

MARK 12

BENDIX

77-44-144

FIGURE 144. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 26

LOCATION - 240°R/14 nmi, over ANTENNA #11

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM

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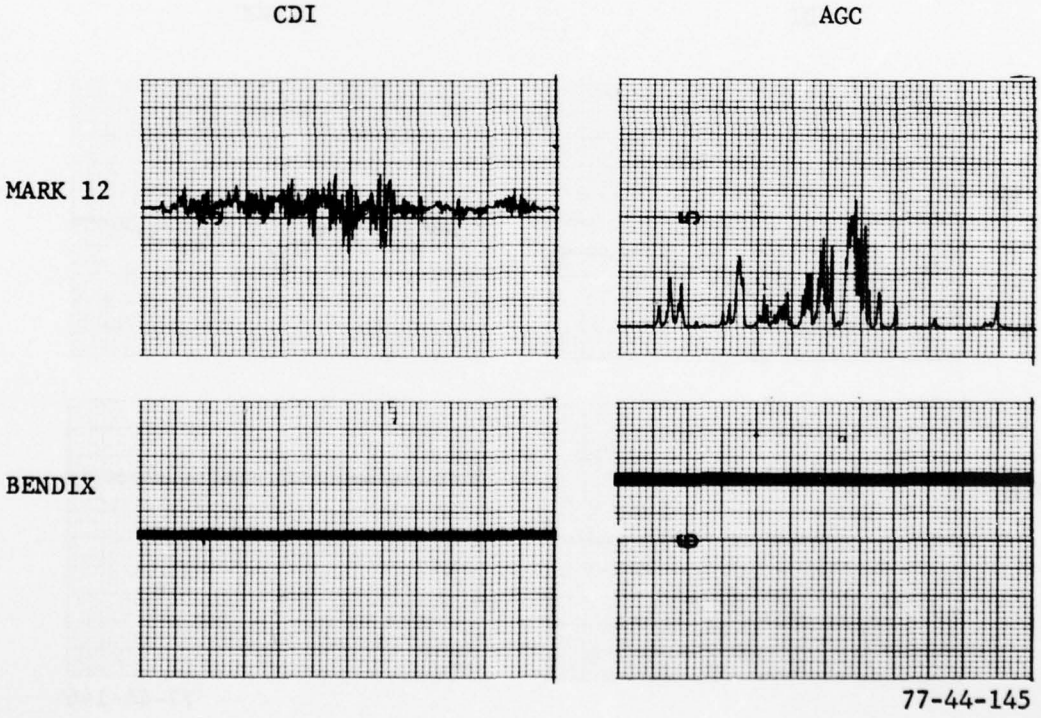

FIGURE 145. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 27

LOCATION - 160°R/17 nmi, turning over cluster of ANTENNAS

AUDIO INTERFERENCES

BENDIX- None

MARK 12- Music

FM SPECTRUM

Blank Video Recording

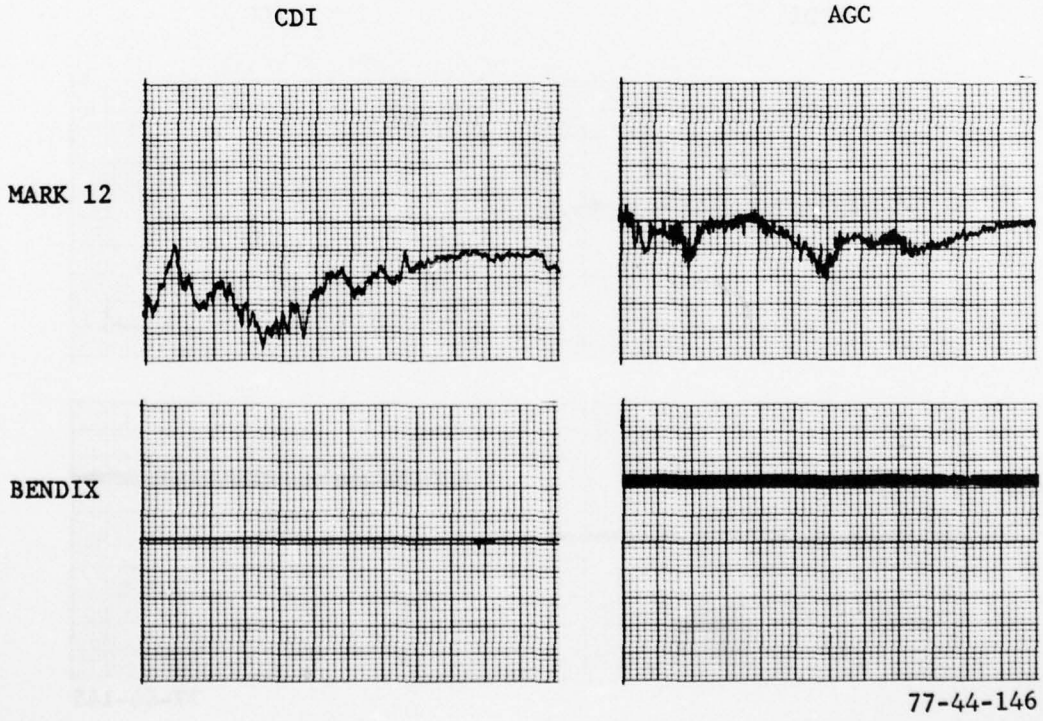

FIGURE 146. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 28

LOCATION - 230°R/14 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Music

FM SPECTRUM

Blank Video Recording

FIGURE 147. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 29

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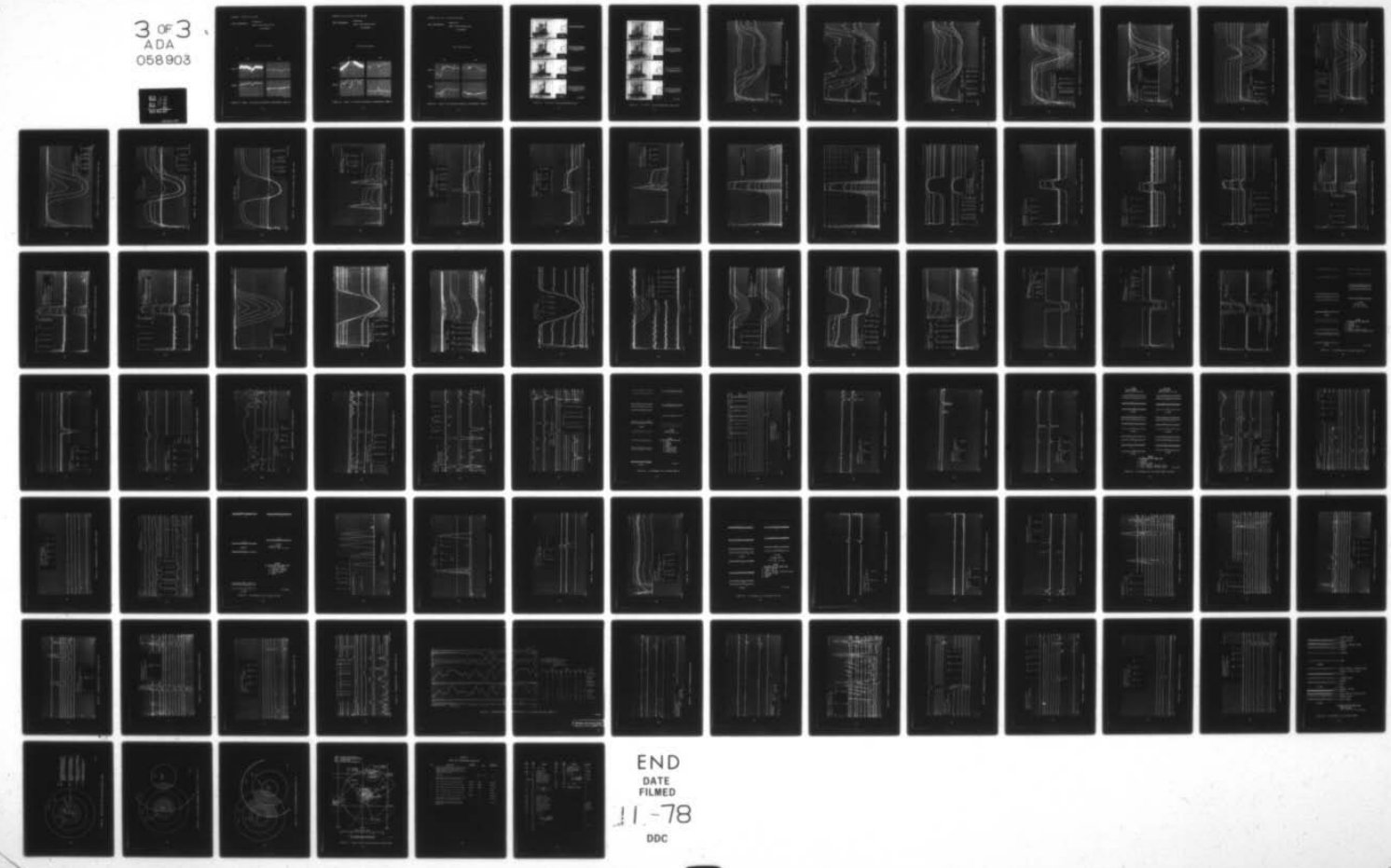

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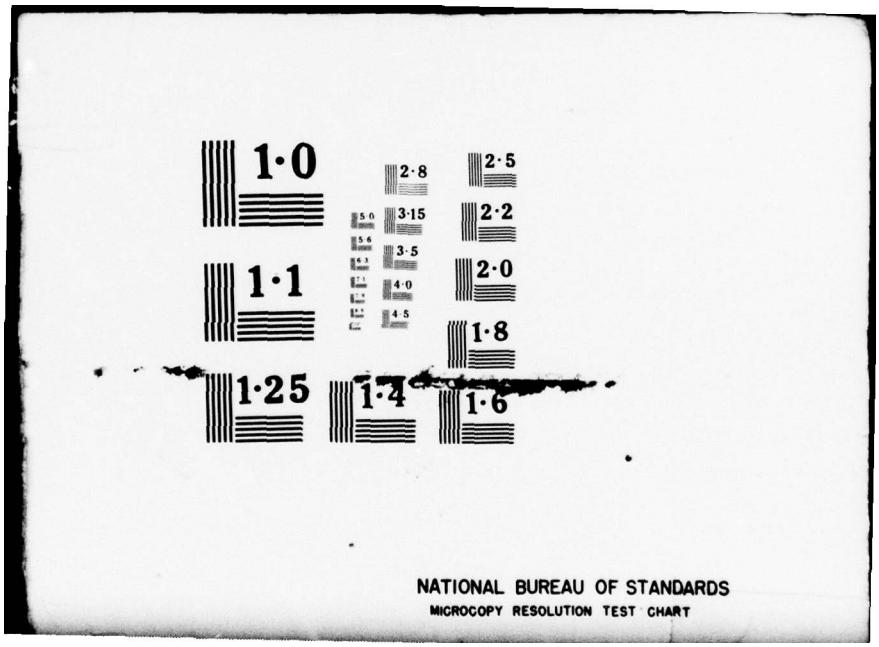
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

LOCATION - 110°R/6 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM

Blank Video Recording

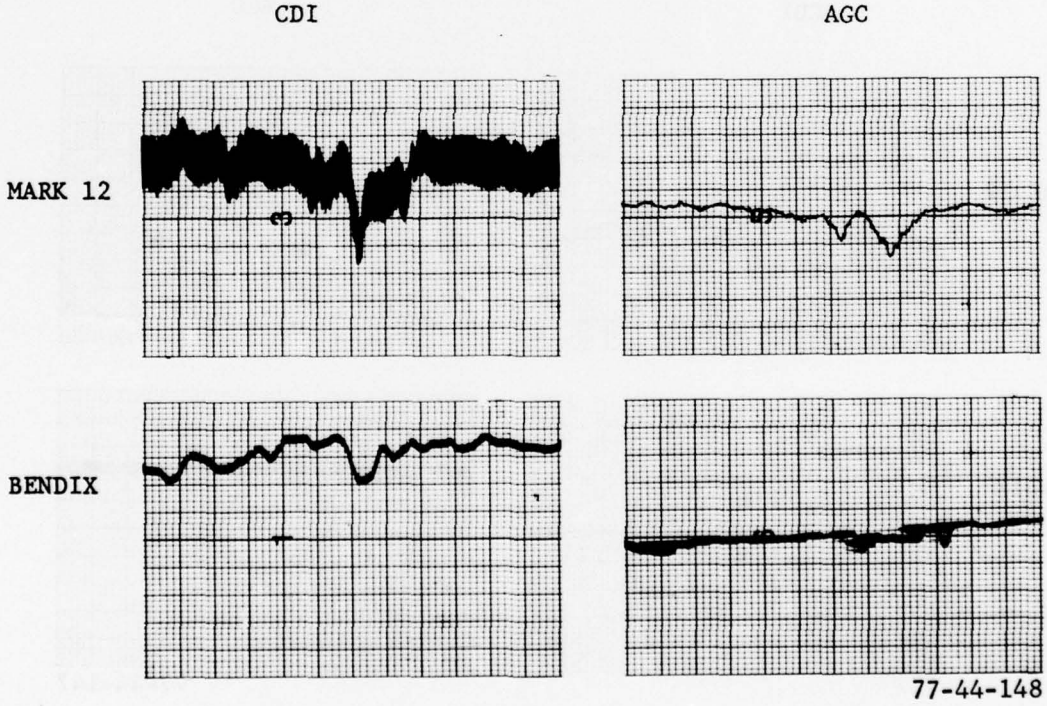


FIGURE 148. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 30

LOCATION - Over Love Field, 9 nmi from GSW

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM

Blank Video Recording

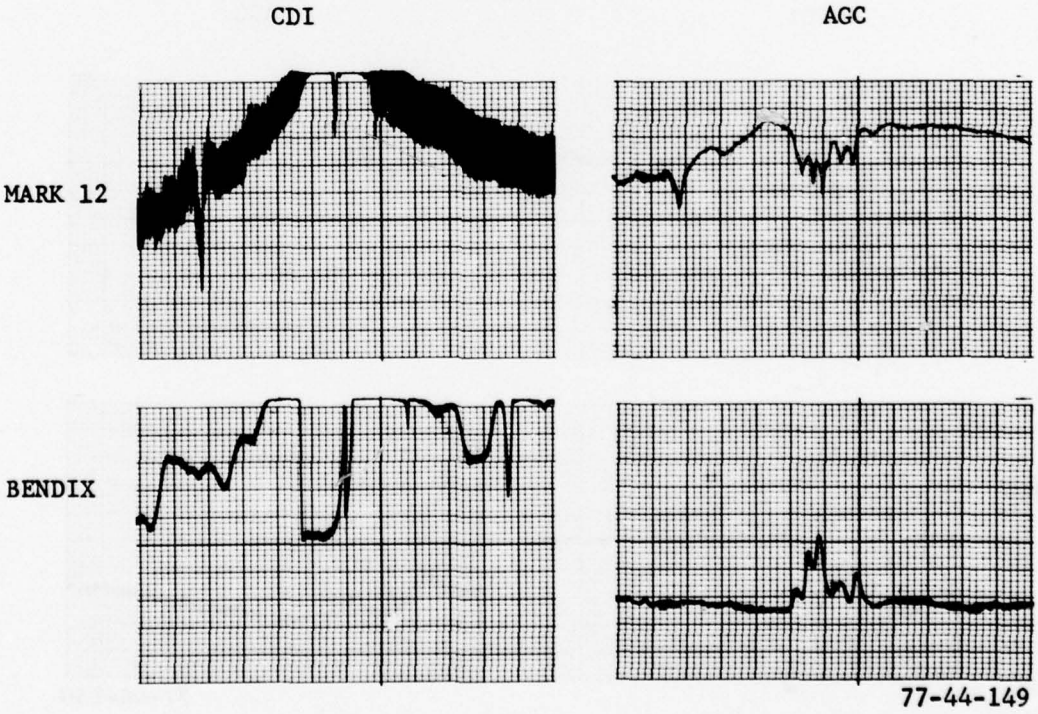


FIGURE 149. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 31

LOCATION - Rwy 17R, 2 nmi from outer marker

AUDIO INTERFERENCES

BENDIX-None

MARK 12-Motorboating Sound

FM SPECTRUM

Blank Video Recording

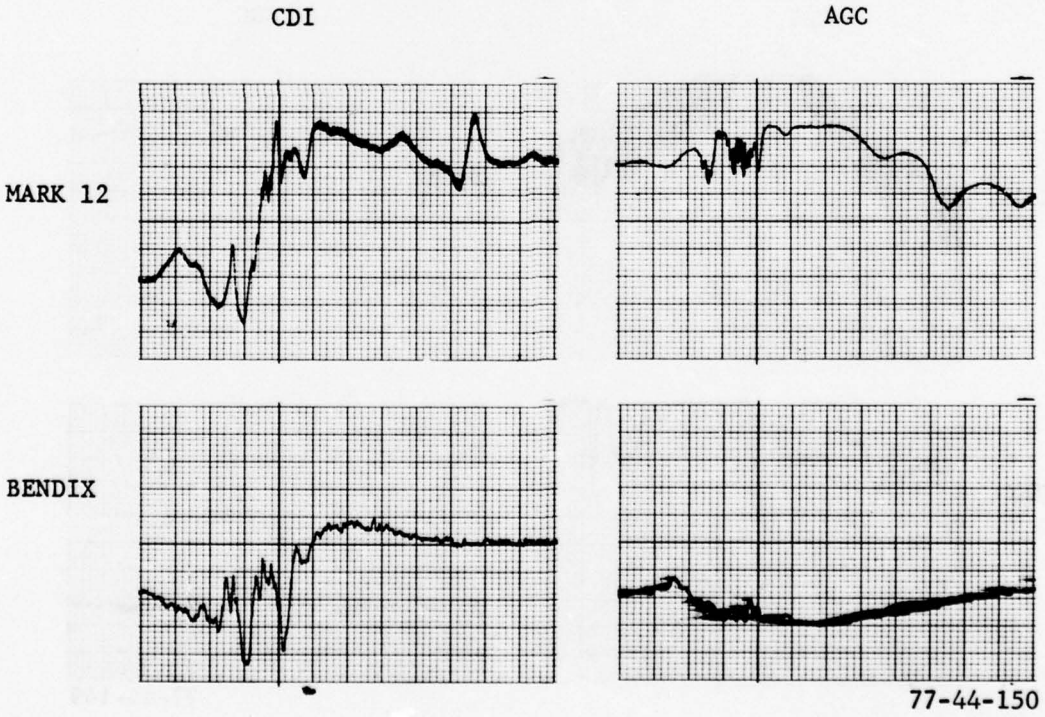
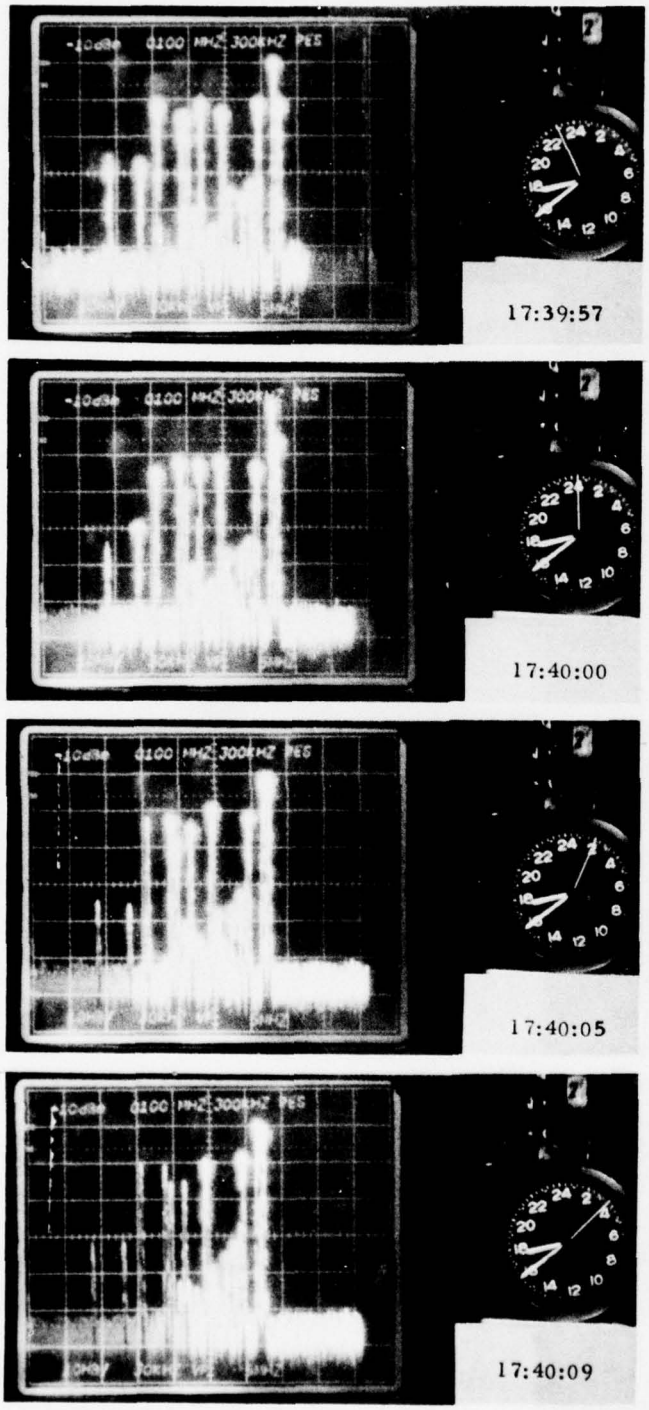


FIGURE 150. DALLAS - LOVE FIELD AND REGIONAL FT WORTH/DALLAS FRAME 32



FM SPECTRUM NO. 1

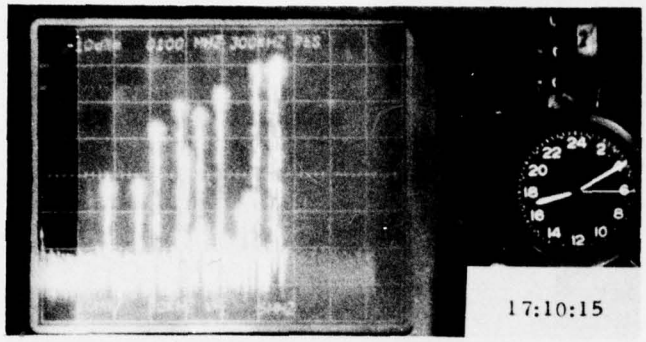
FM SPECTRUM NO. 2
(3 SECONDS LATER)
THAN NO. 1

FM SPECTRUM NO. 3
(8 SECONDS LATER)
THAN NO. 1

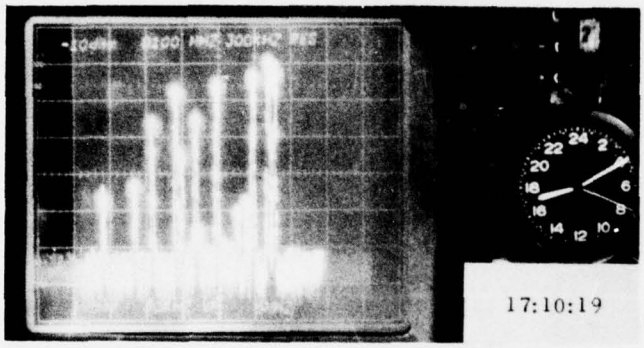
FM SPECTRUM NO. 4
(12 SECONDS LATER)
THAN NO. 1

77-44-151

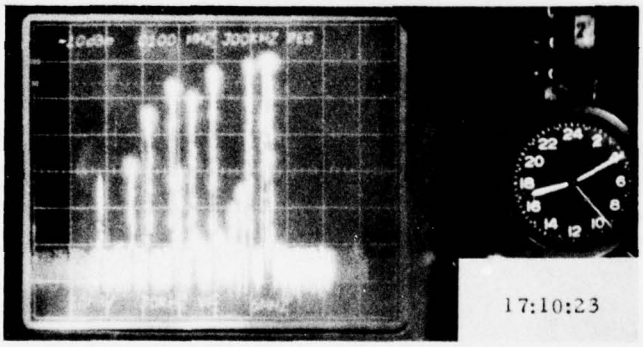
FIGURE 151. FM SPECTRUM, BIRMINGHAM-MUNICIPAL, RWY 5



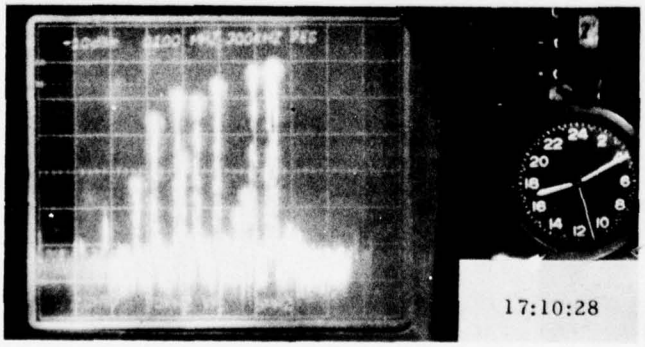
FM SPECTRUM NO. 1



FM SPECTRUM NO. 2
(4 SECONDS LATER)
THAN NO. 1



FM SPECTRUM NO. 3
(8 SECONDS LATER)
THAN NO. 1



FM SPECTRUM NO. 4
(13 SECONDS LATER)
THAN NO. 1

77-44-152

FIGURE 152. FM SPECTRUM, BIRMINGHAM-MUNICIPAL, ORBIT 5 NMI

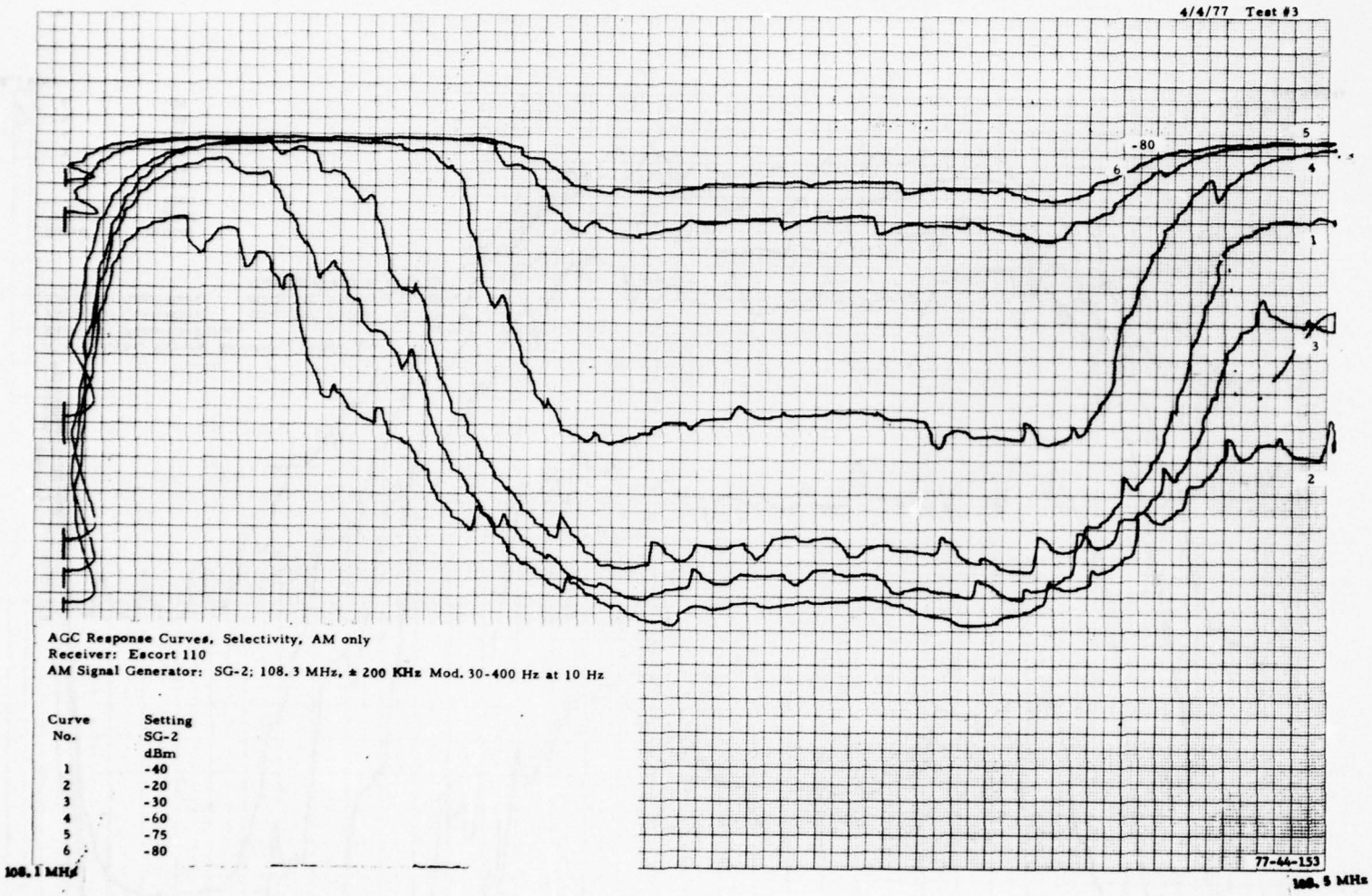


FIGURE 153. SELECTIVITY, AM SIGNAL 108.3 MHz ESCORT (NAV)

FIGURE 154. SELECTIVITY, 1 AM & 1 FM SIGNAL ESCORT (NAV)

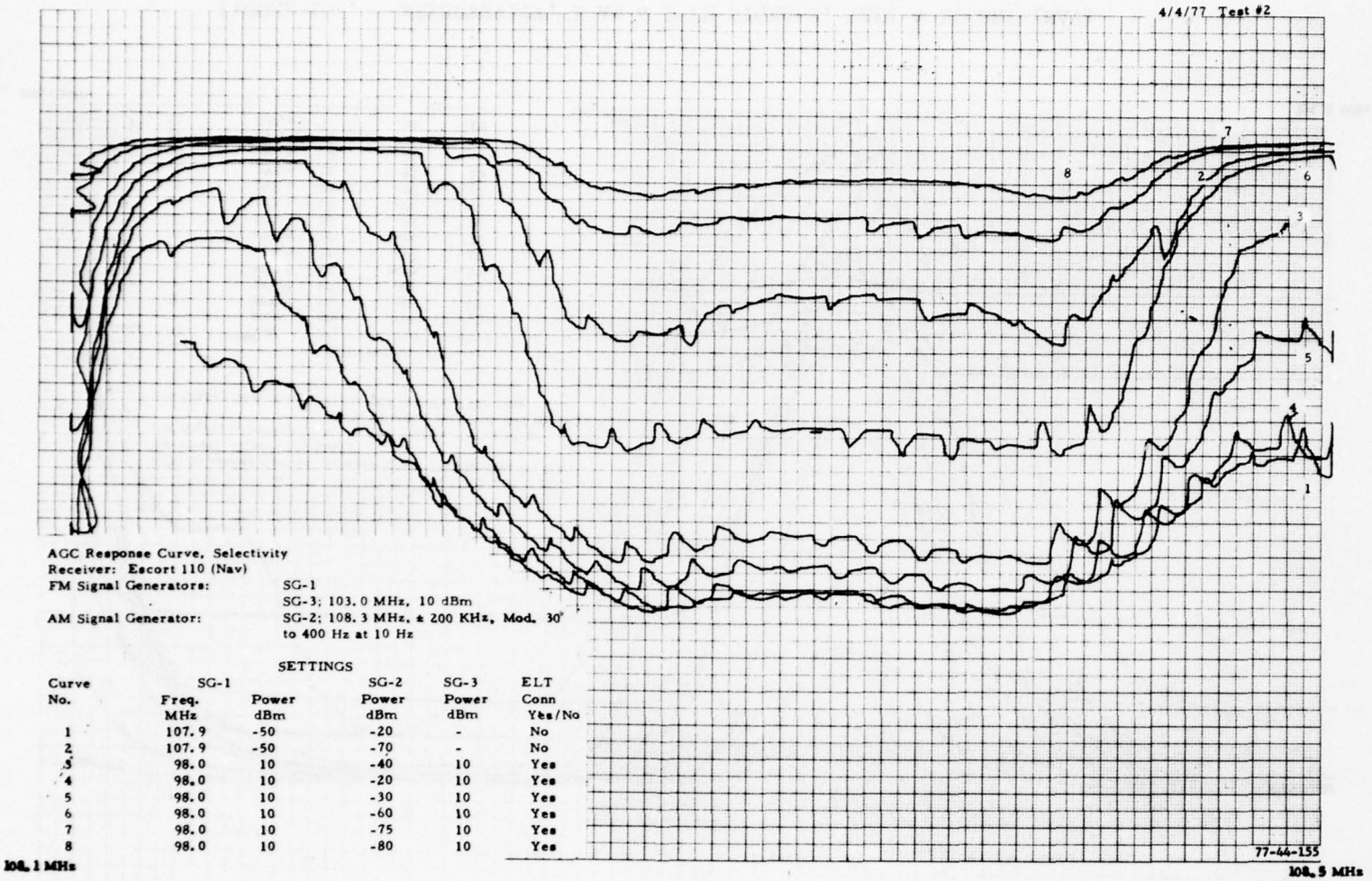


FIGURE 155. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 2 ESCORT (NAV)

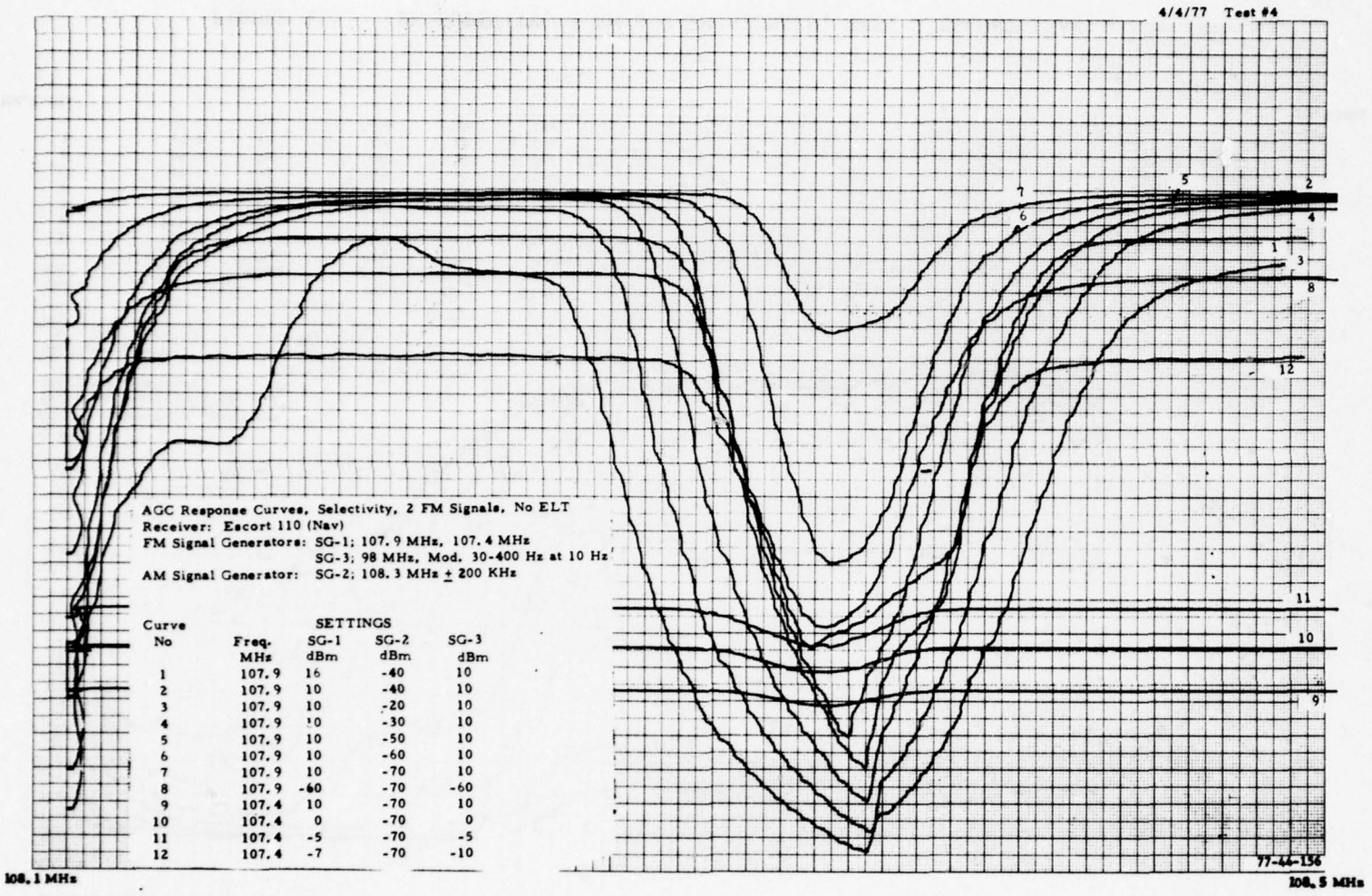


FIGURE 156. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 4 ESCORT (NAV)

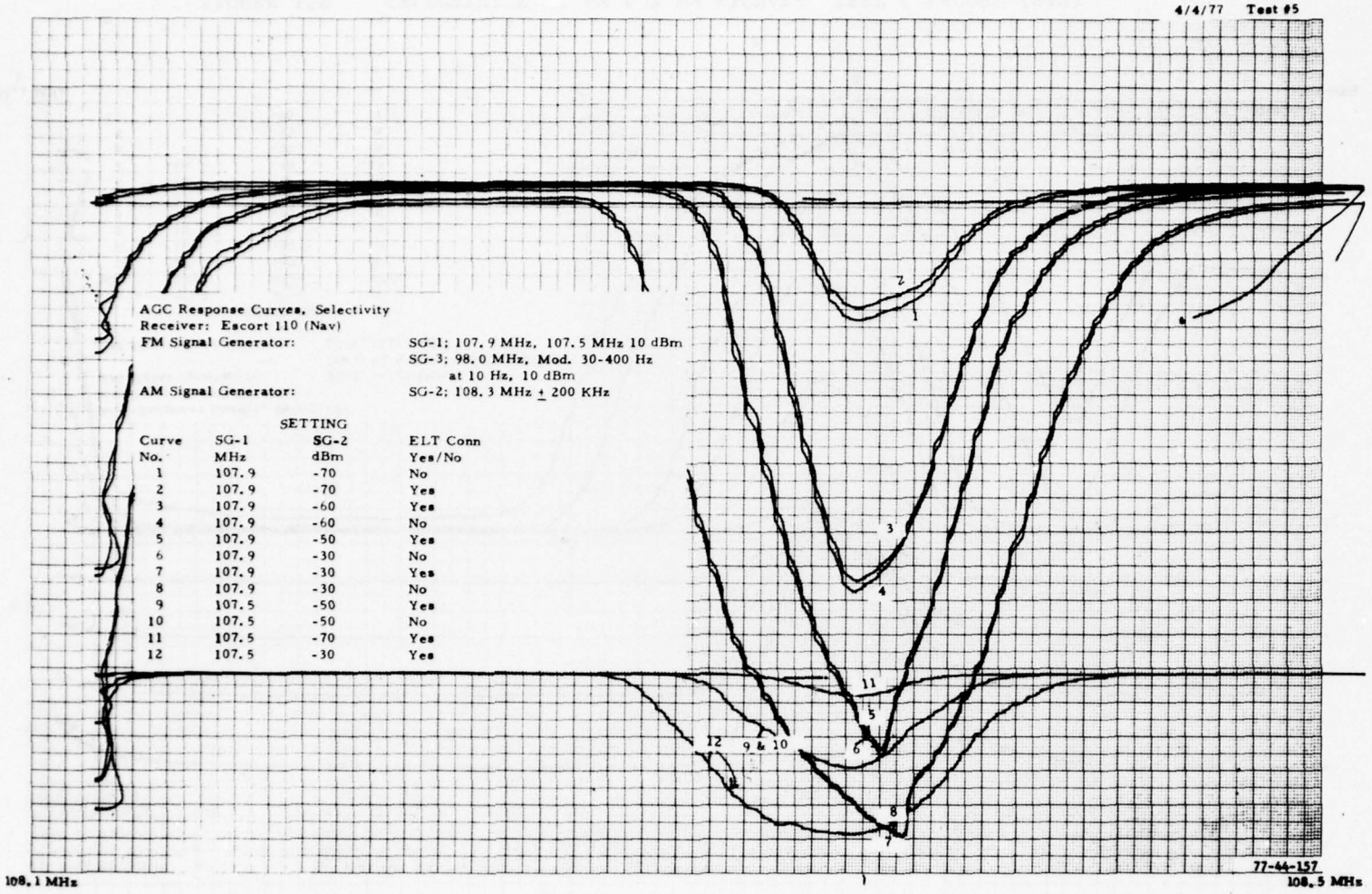


FIGURE 157. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 5 ESCORT (NAV)

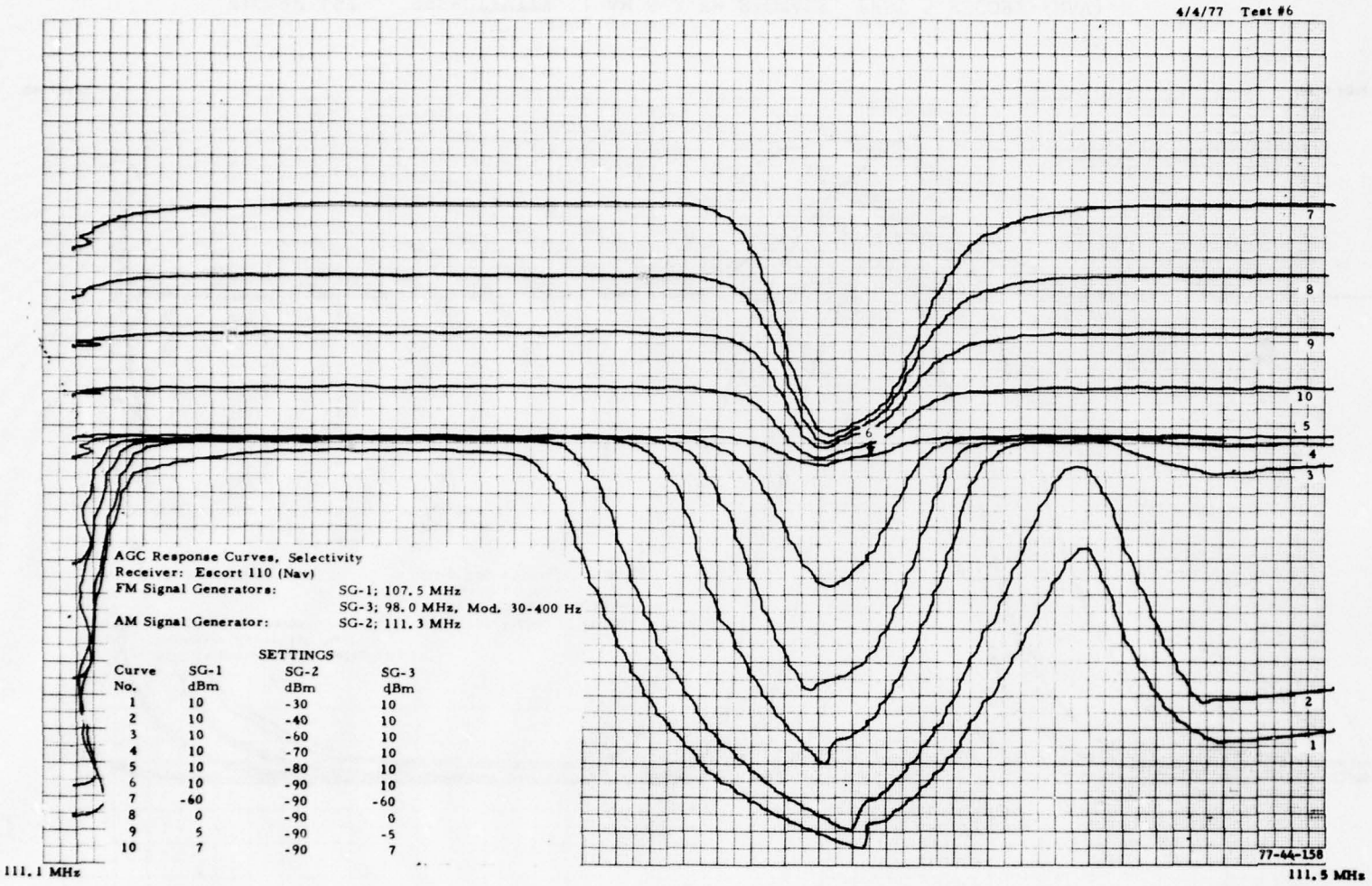


FIGURE 158. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 6 ESCORT (NAV)

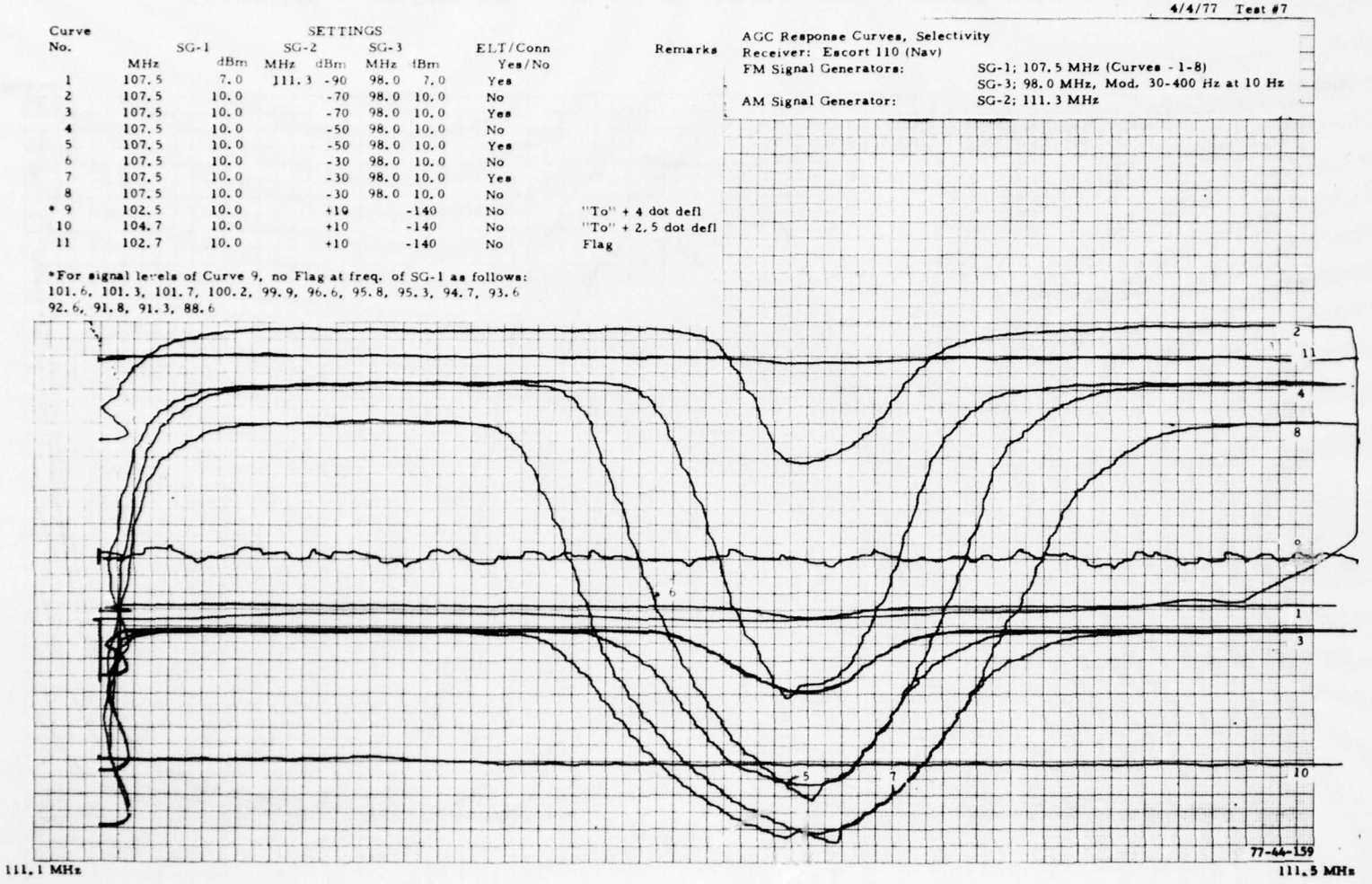


FIGURE 159. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 7 ESCORT (NAV)

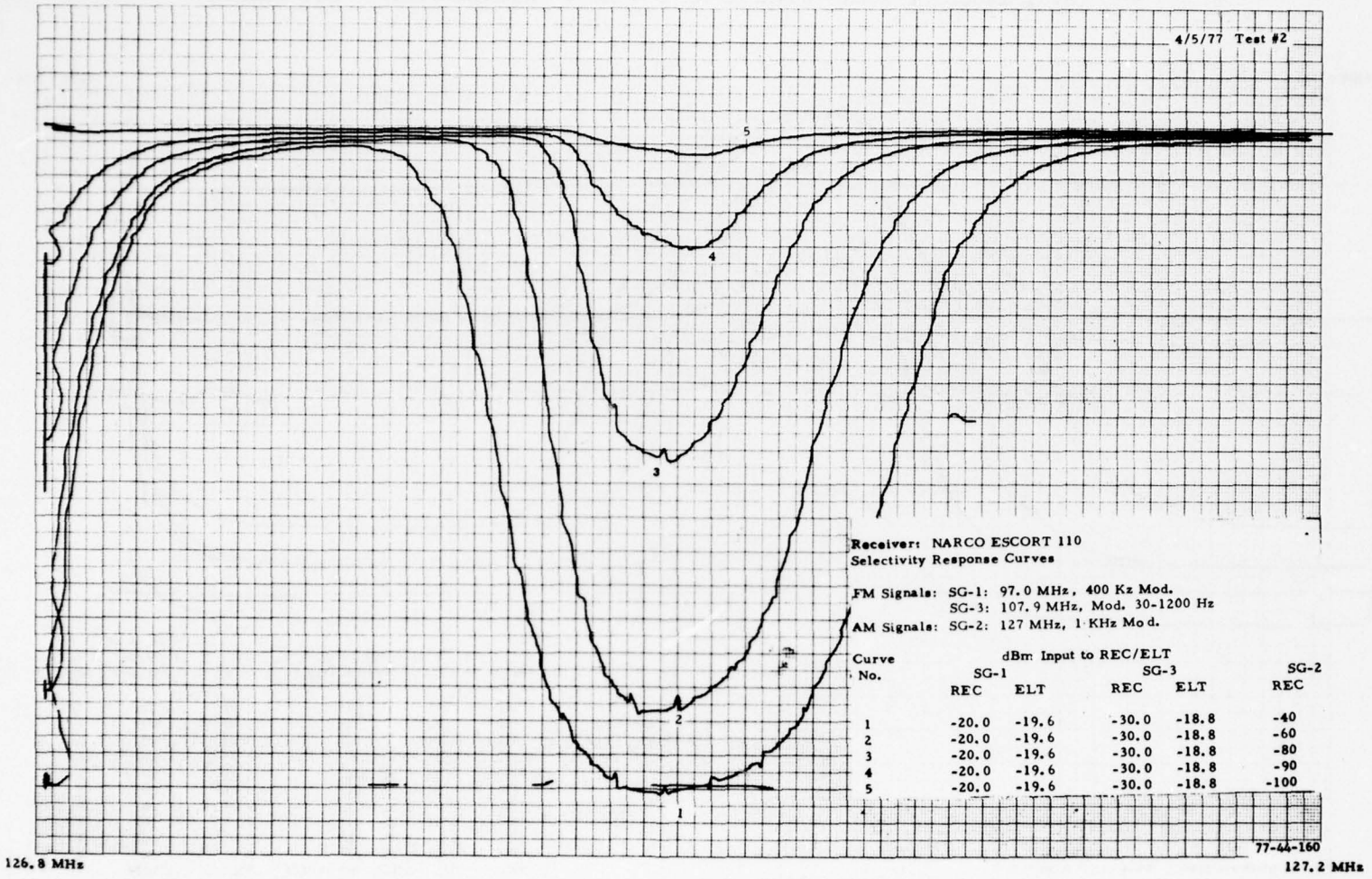
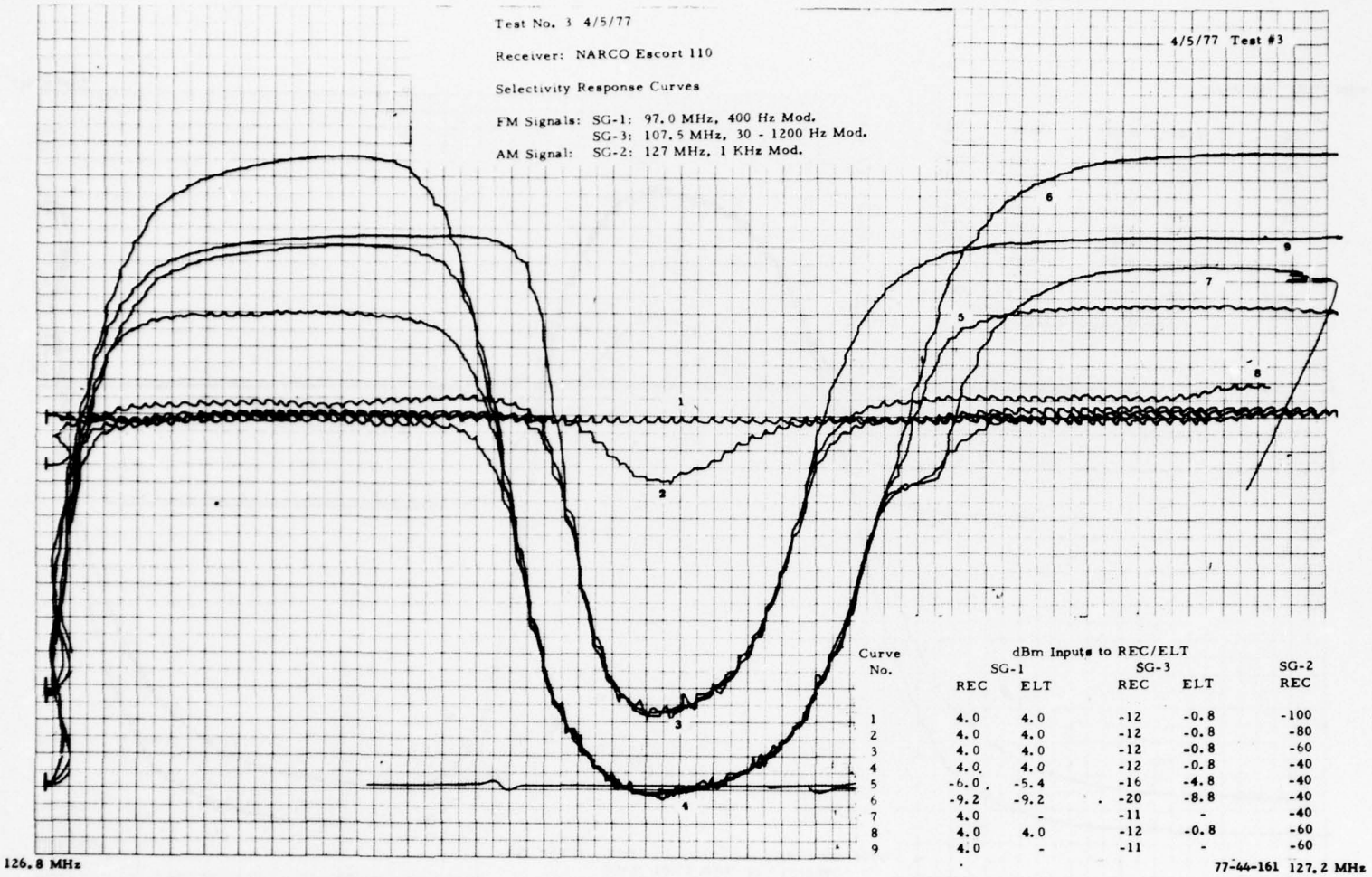
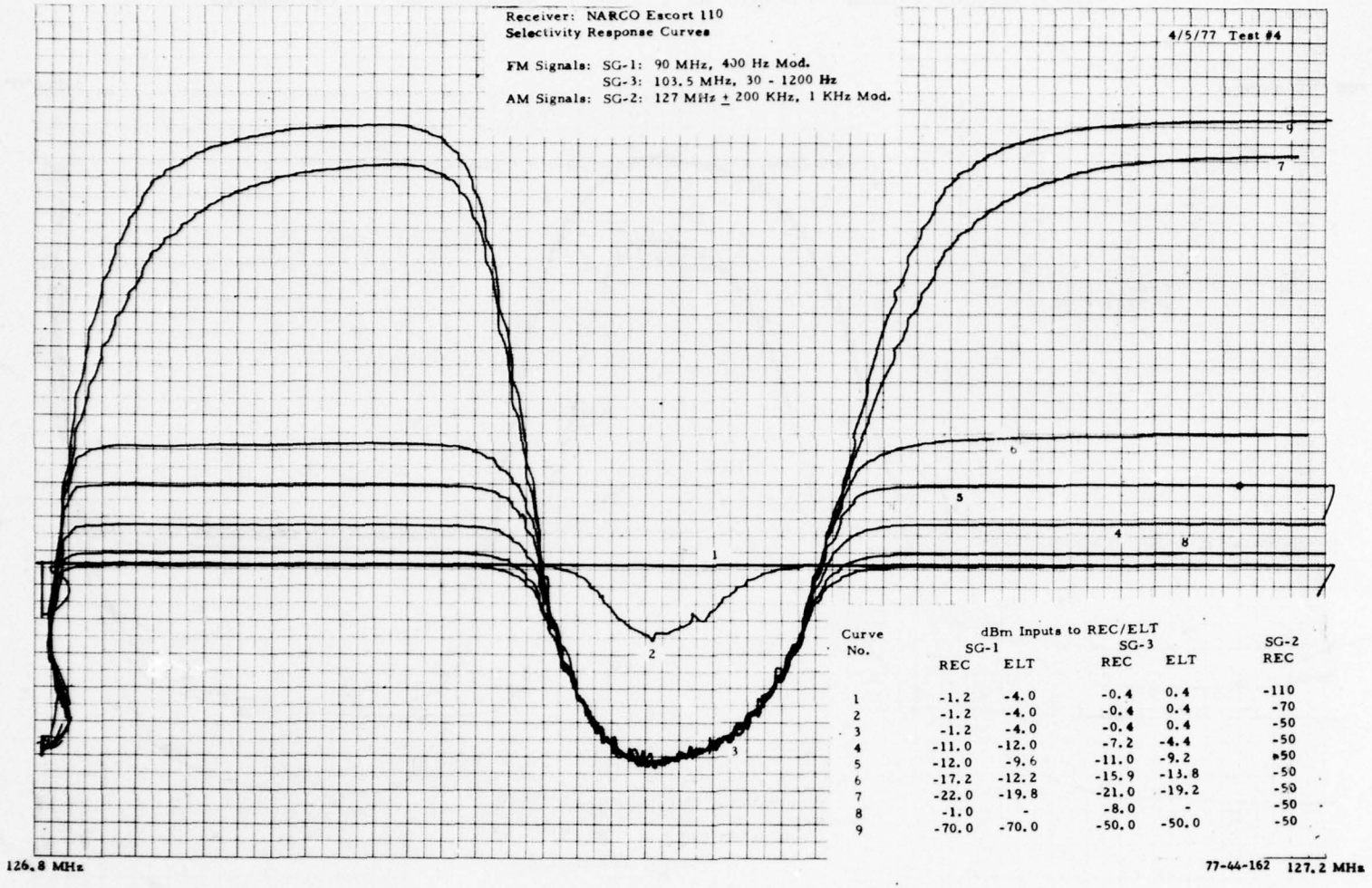


FIGURE 160. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 2 ESCORT (COM)



Curve No.	dBm Inputs to REC/ELT SG-1 REC	SG-1 ELT	SG-3 REC	SG-3 ELT	SG-2 REC
1	4.0	4.0	-12	-0.8	-100
2	4.0	4.0	-12	-0.8	-80
3	4.0	4.0	-12	-0.8	-60
4	4.0	4.0	-12	-0.8	-40
5	-6.0	-5.4	-16	-4.8	-40
6	-9.2	-9.2	-20	-8.8	-40
7	4.0	-	-11	-	-40
8	4.0	4.0	-12	-0.8	-60
9	4.0	-	-11	-	-60

FIGURE 161. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 3 ESCORT (COM)



Curve No.	dBm Inputs to REC/ELT SG-1 REC	SG-1 ELT	SG-3 REC	SG-3 ELT	SG-2 REC
1	-1.2	-4.0	-0.4	0.4	-110
2	-1.2	-4.0	-0.4	0.4	-70
3	-1.2	-4.0	-0.4	0.4	-50
4	-11.0	-12.0	-7.2	-4.4	-50
5	-12.0	-9.6	-11.0	-9.2	-50
6	-17.2	-12.2	-15.9	-13.8	-50
7	-22.0	-19.8	-21.0	-19.2	-50
8	-1.0	-	-8.0	-	-50
9	-70.0	-70.0	-50.0	-50.0	-50

FIGURE 162. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 4 ESCORT (COM)

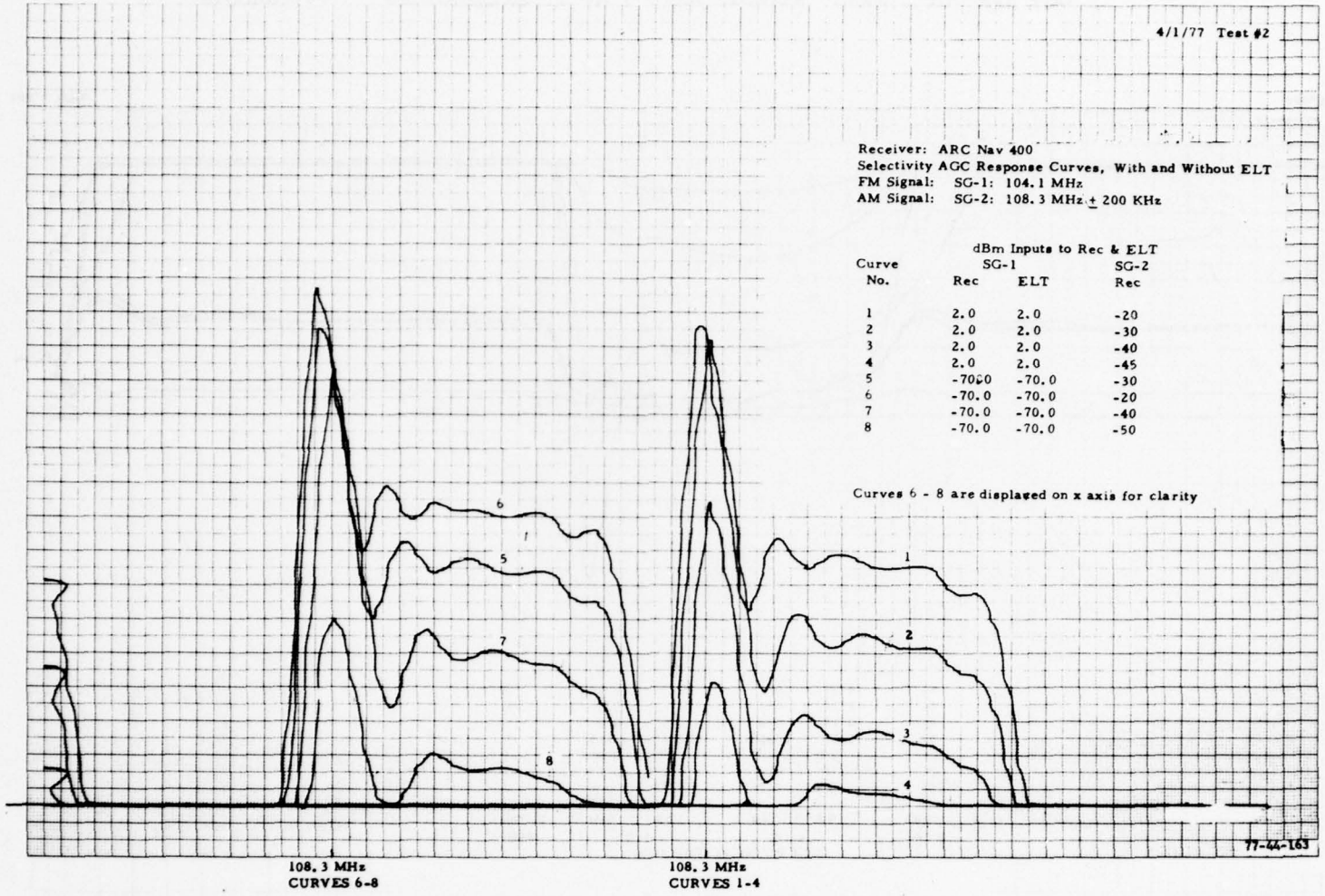


FIGURE 163. SELECTIVITY, 1 AM & 1 FM SIGNALS, TEST 2 ARC NAV 400

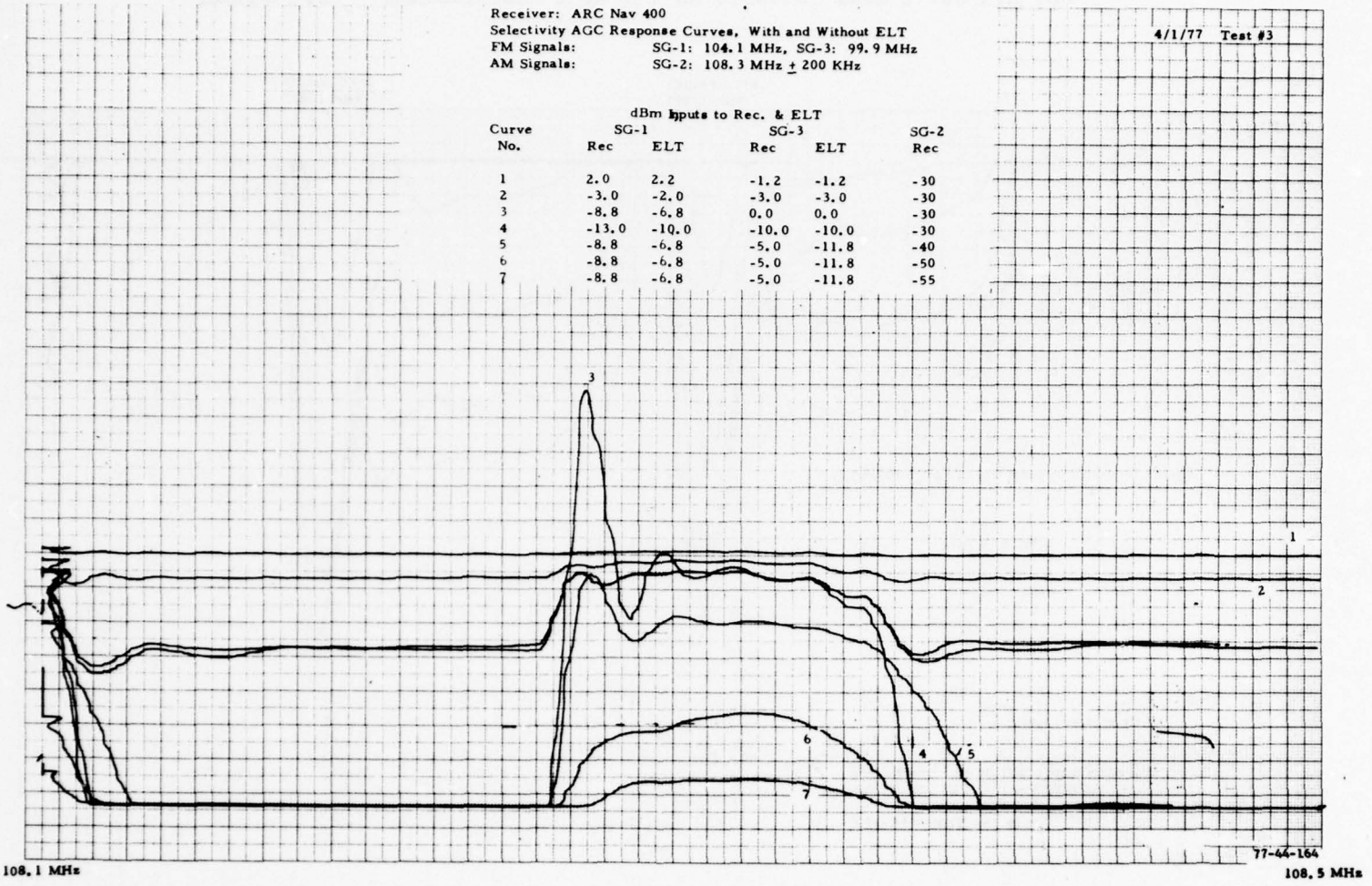


FIGURE 164. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 3 ARC NAV 400

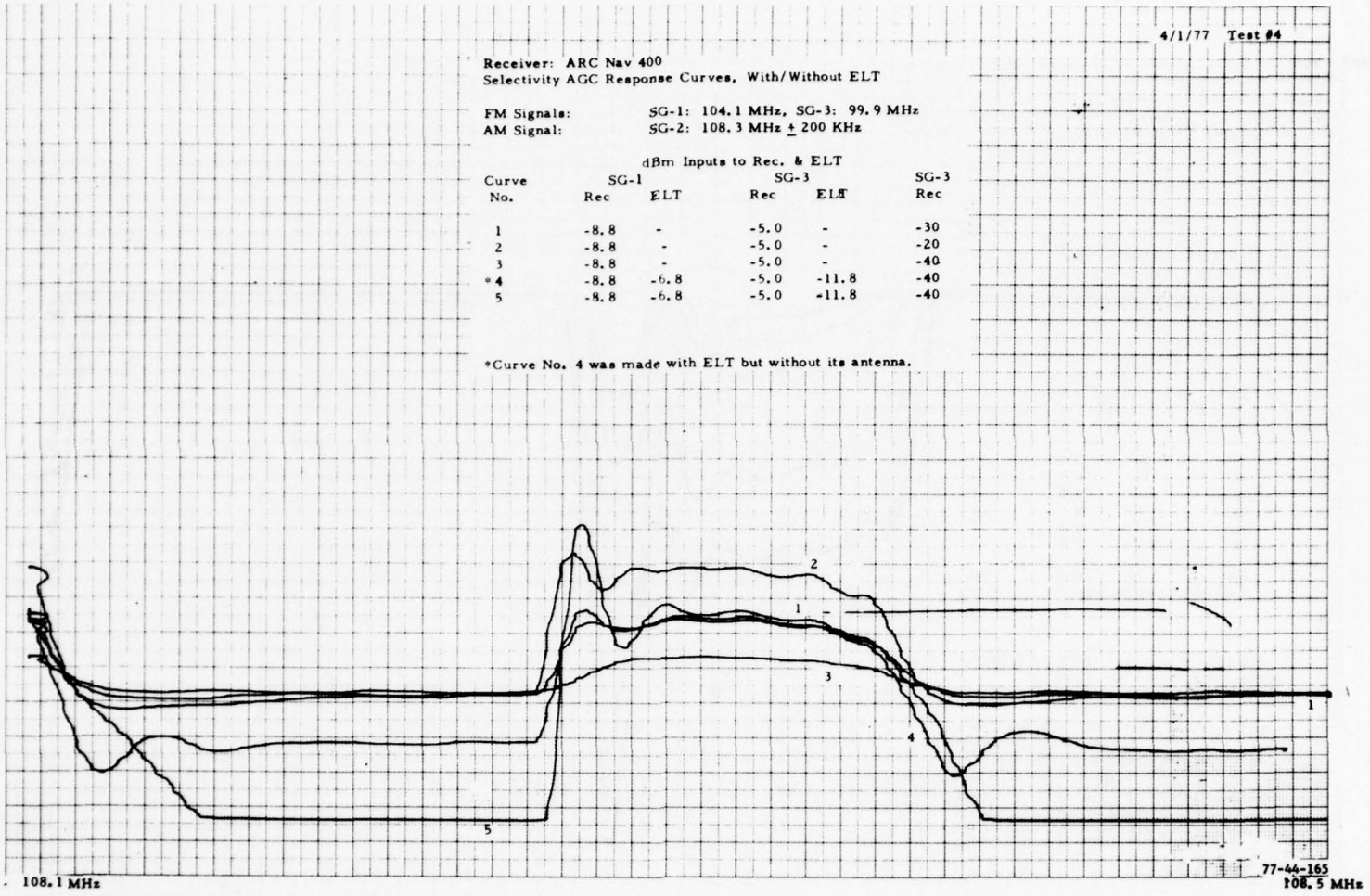


FIGURE 165. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 4 ARC NAV 400

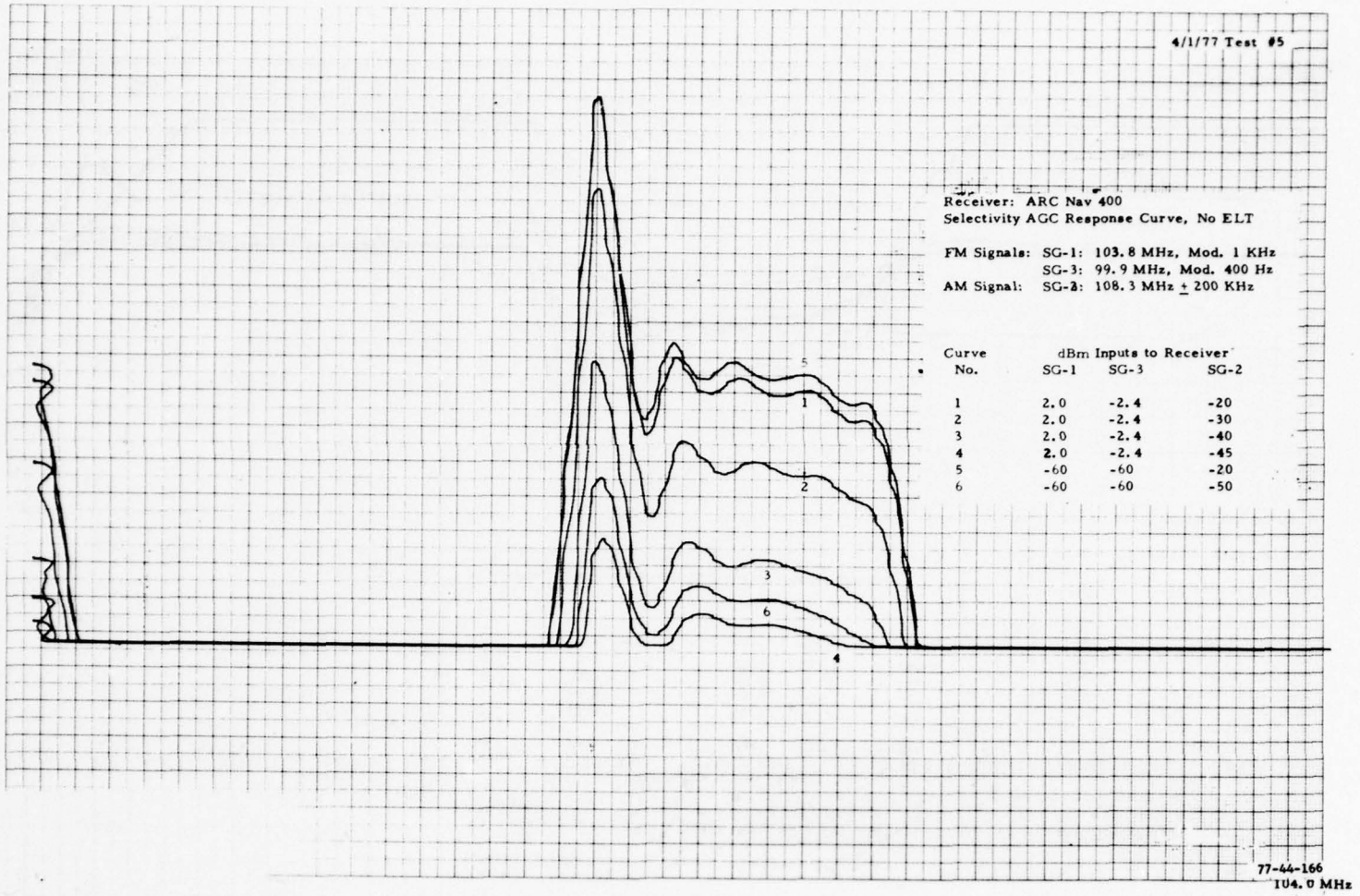


FIGURE 166. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 5 ARC NAV 400

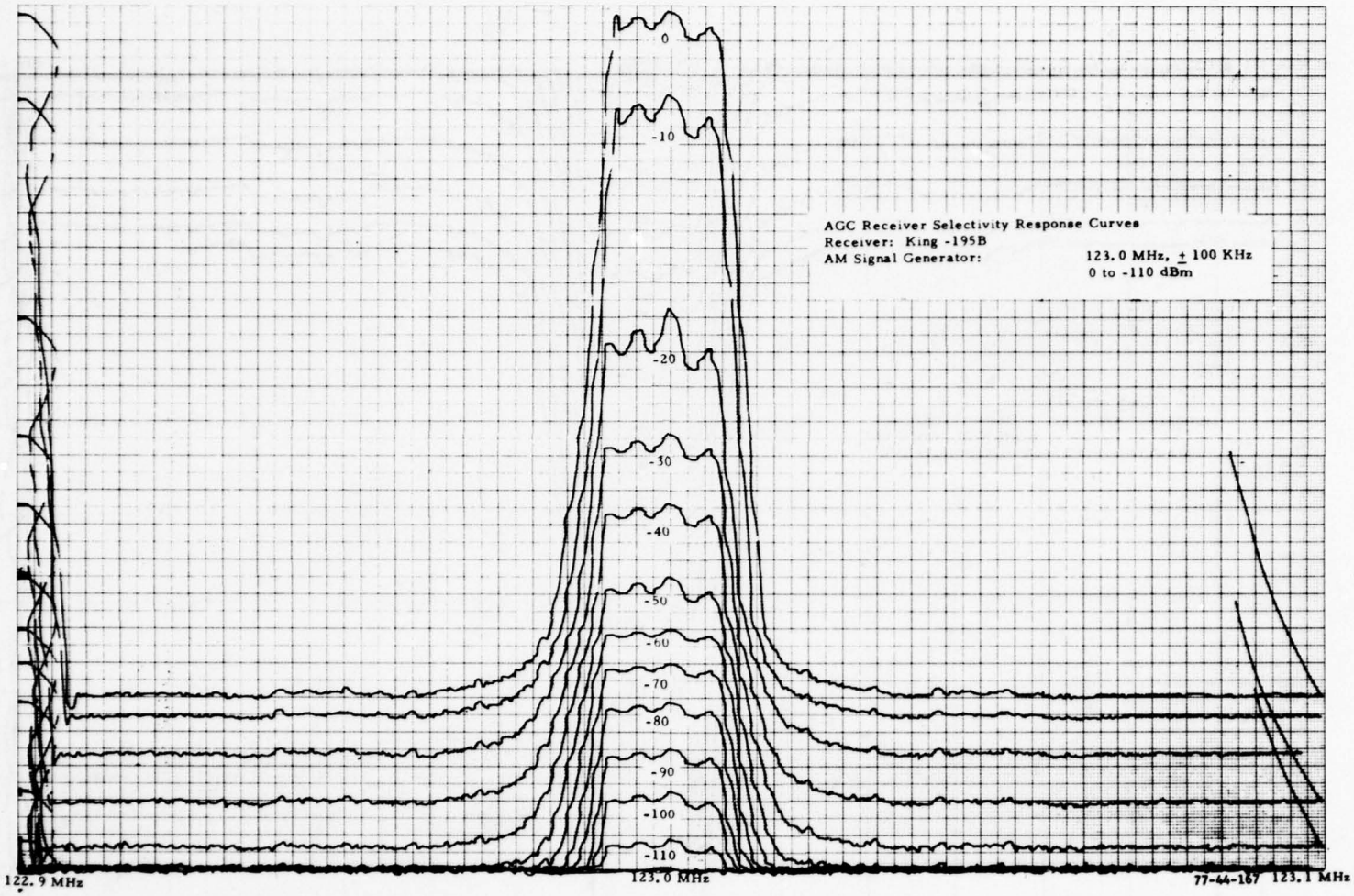


FIGURE 167. SELECTIVITY, AM SIGNAL 123.0 MHz KING 195B

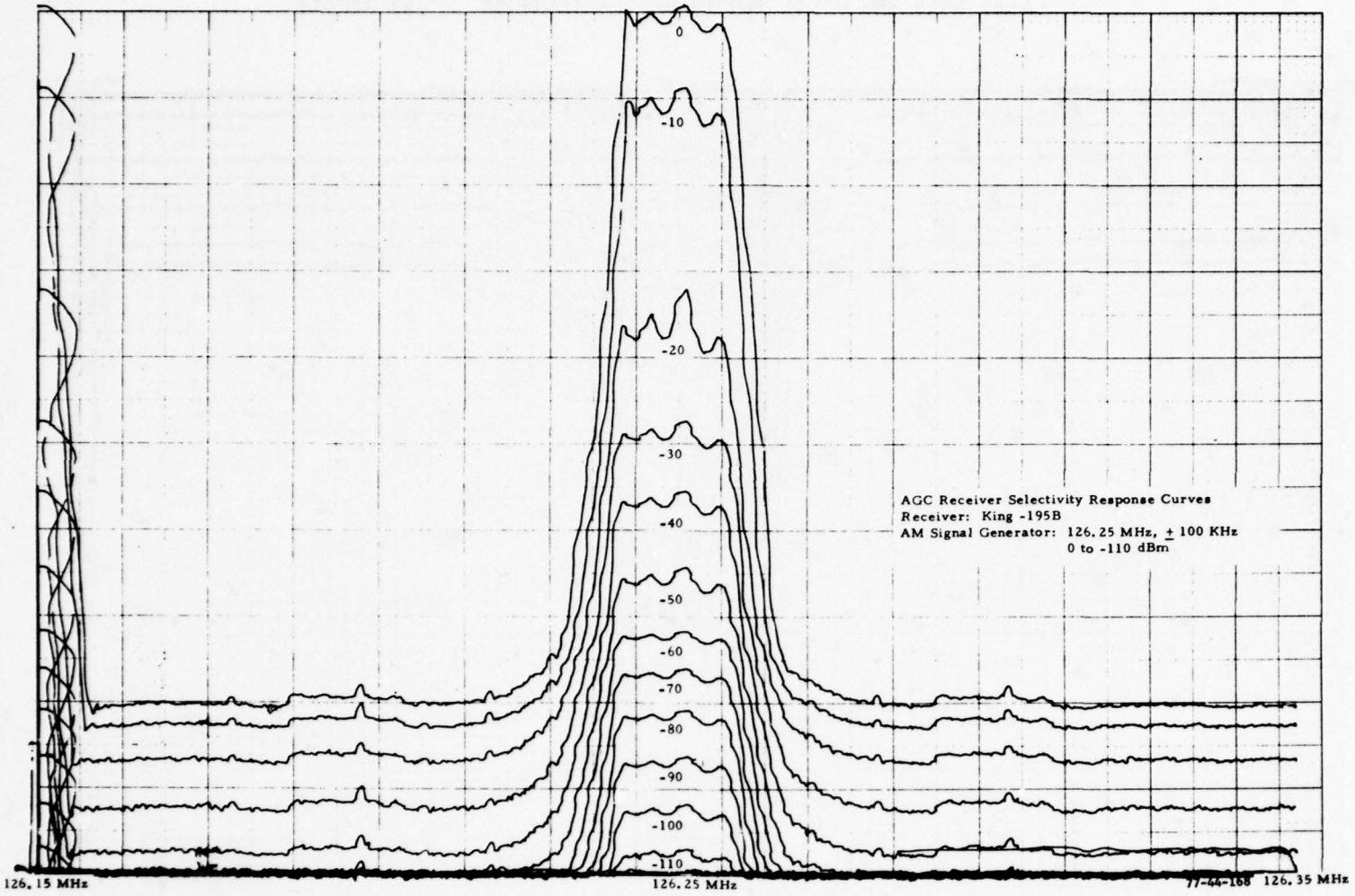
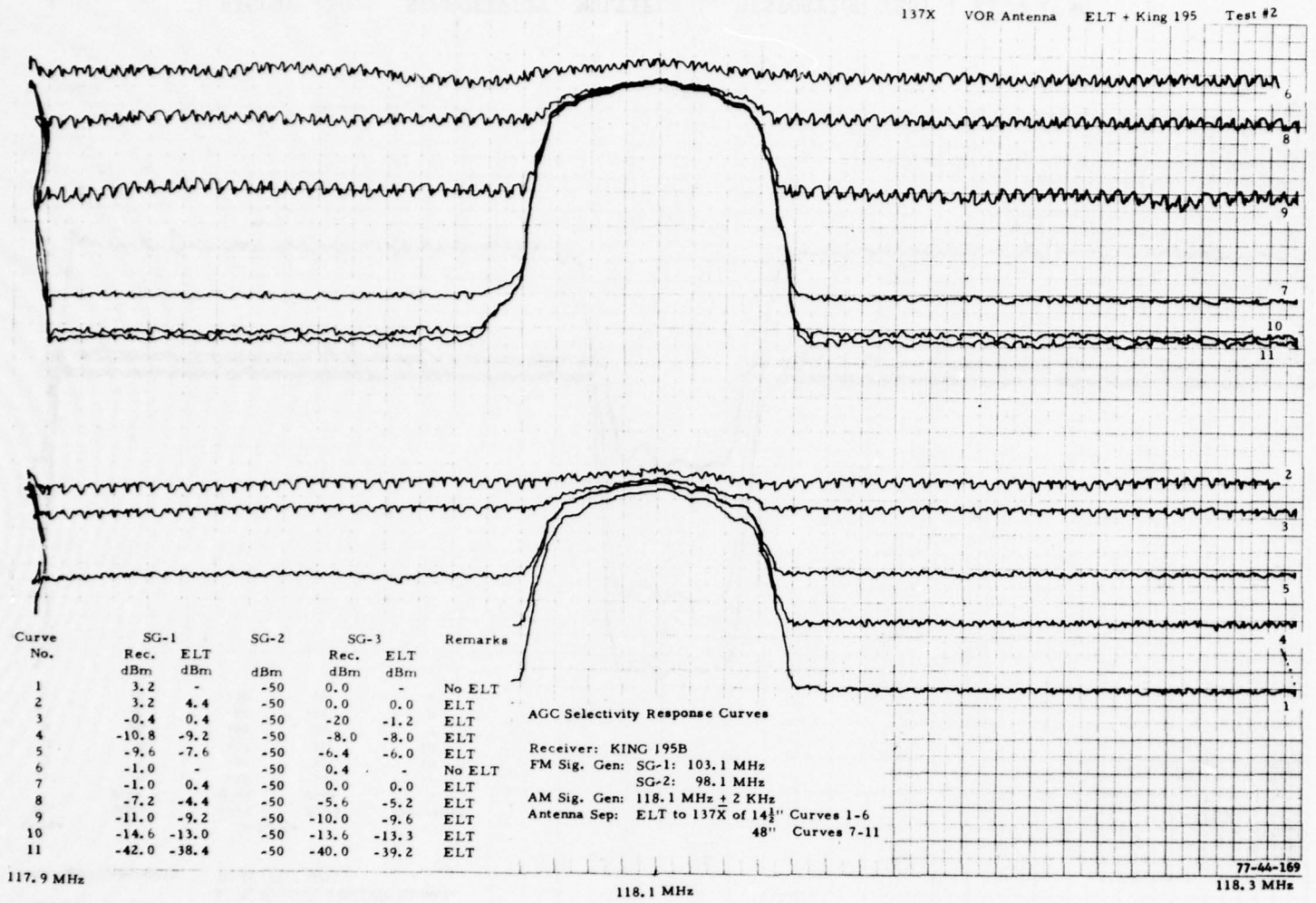


FIGURE 168. SELECTIVITY, AM SIGNAL 126.25 MHz KING 195B



Curve No.	SG-1 Rec. dBm	SG-1 ELT dBm	SG-2 dBm	SG-3 Rec. dBm	SG-3 ELT dBm	Remarks
1	3.2	-	-50	0.0	-	No ELT
2	3.2	4.4	-50	0.0	0.0	ELT
3	-0.4	0.4	-50	-20	-1.2	ELT
4	-10.8	-9.2	-50	-8.0	-8.0	ELT
5	-9.6	-7.6	-50	-6.4	-6.0	ELT
6	-1.0	-	-50	0.4	-	No ELT
7	-1.0	0.4	-50	0.0	0.0	ELT
8	-7.2	-4.4	-50	-5.6	-5.2	ELT
9	-11.0	-9.2	-50	-10.0	-9.6	ELT
10	-14.6	-13.0	-50	-13.6	-13.3	ELT
11	-42.0	-38.4	-50	-40.0	-39.2	ELT

FIGURE 169. SELECTIVITY, 1 AM & 2 FM SIGNALS, TEST 2 KING 195B

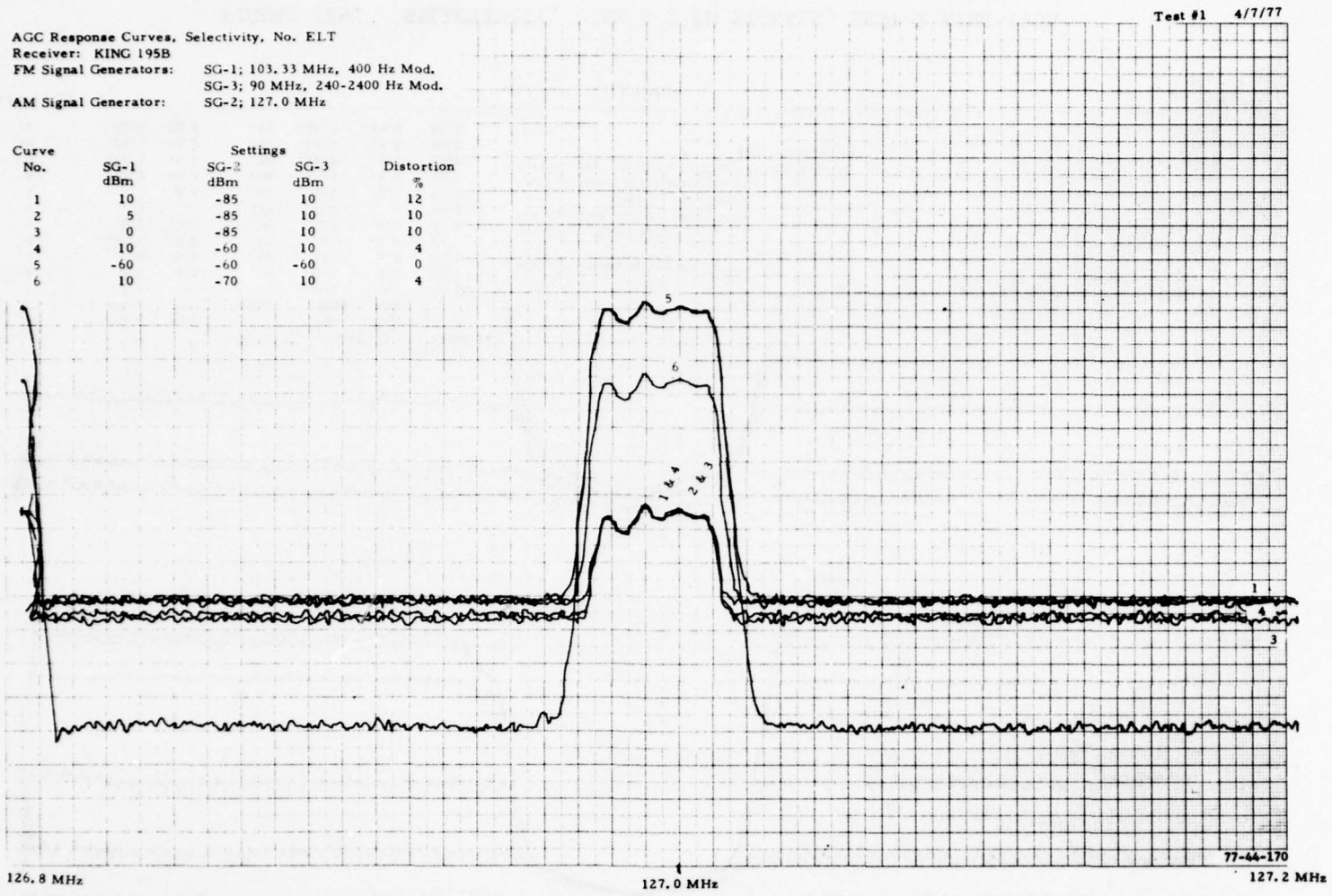


FIGURE 170. SELECTIVITY, MULTIPLE 1, DISTORTION TEST 1 KING 195B

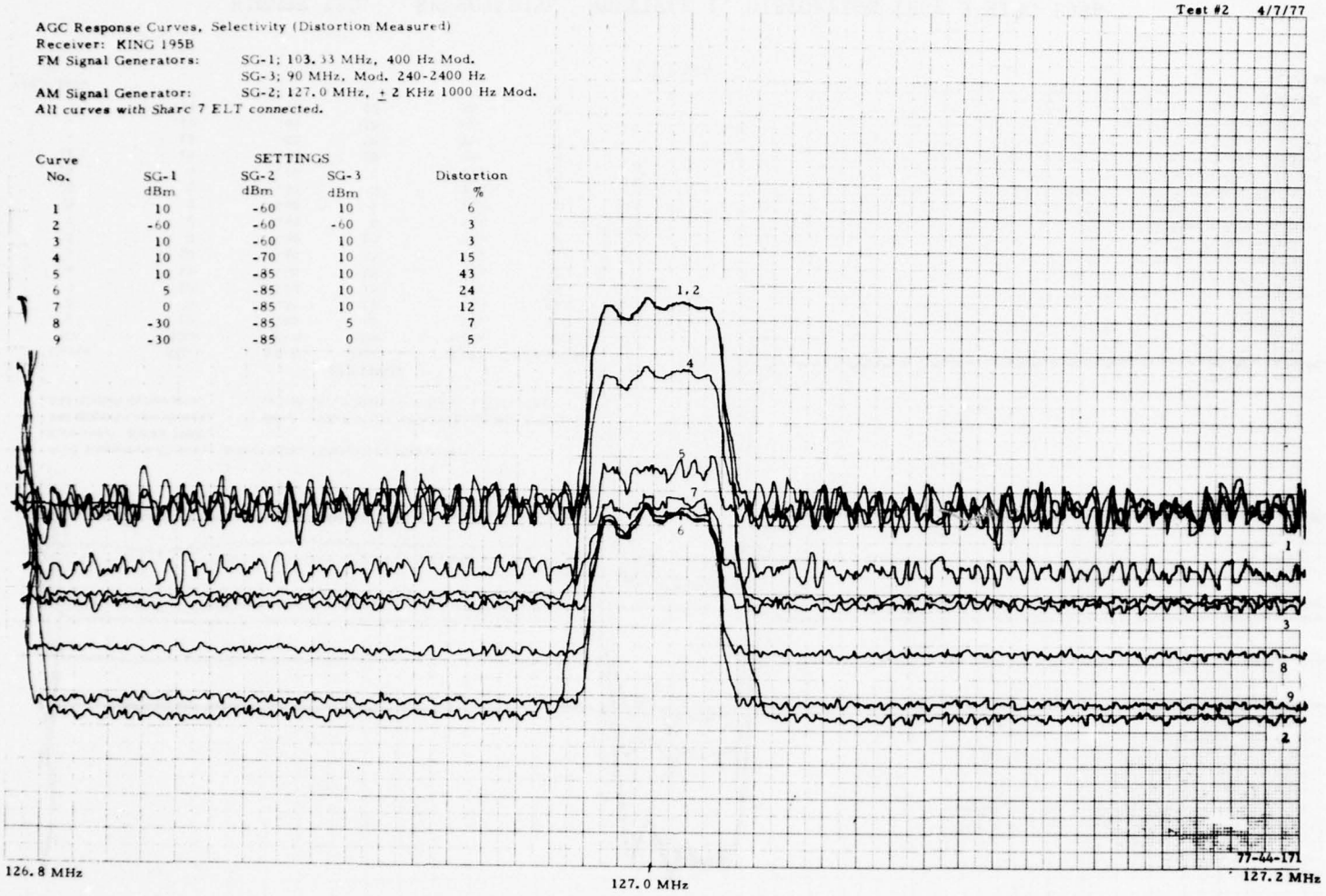


FIGURE 171. SELECTIVITY, MULTIPLE 1, DISTORTION TEST 2 KING 195B

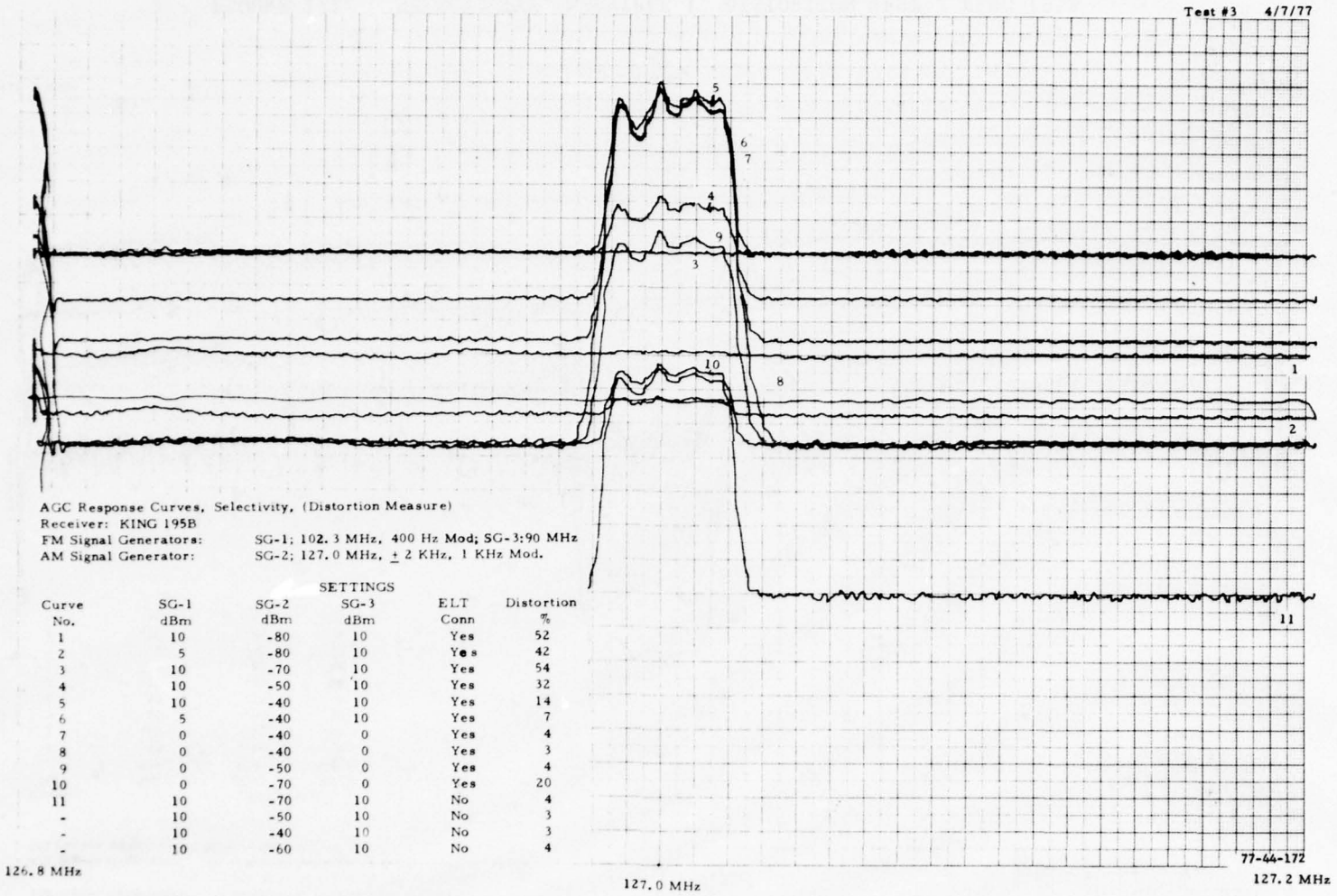
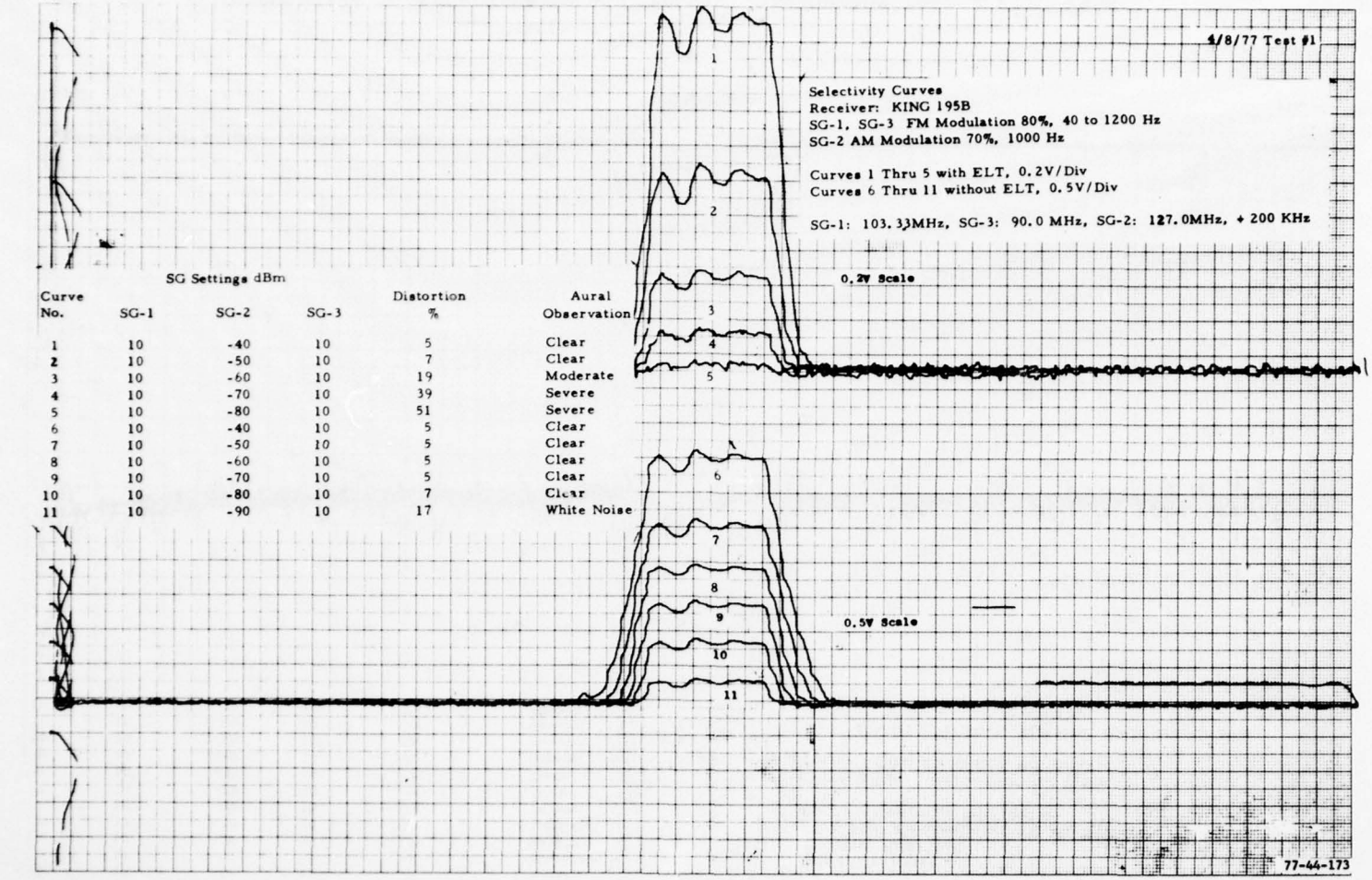


FIGURE 172. SELECTIVITY, MULTIPLE 1, DISTORTION TEST 3 KING 195B



Curve No.	SG Settings dBm SG-1	SG-2	SG-3	Distortion %	Aural Observation
1	10	-40	10	5	Clear
2	10	-50	10	7	Clear
3	10	-60	10	19	Moderate
4	10	-70	10	39	Severe
5	10	-80	10	51	Severe
6	10	-40	10	5	Clear
7	10	-50	10	5	Clear
8	10	-60	10	5	Clear
9	10	-70	10	5	Clear
10	10	-80	10	7	Clear
11	10	-90	10	17	White Noise

FIGURE 173. SELECTIVITY, MULTIPLE 2, DISTORTION TEST 1 KING 195B

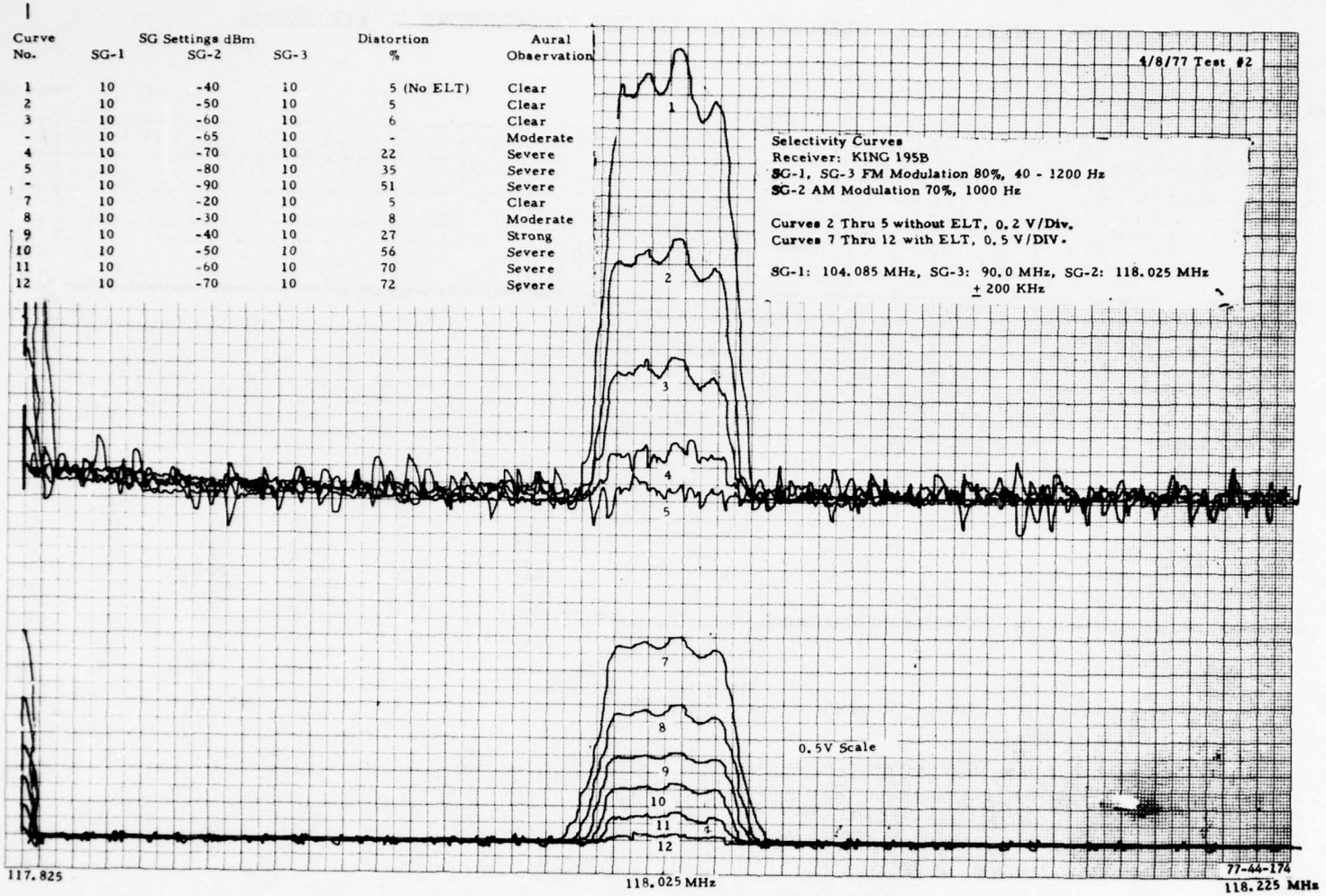


FIGURE 174. SELECTIVITY, MULTIPLE 3, DISTORTION TEST 2 KING 195B

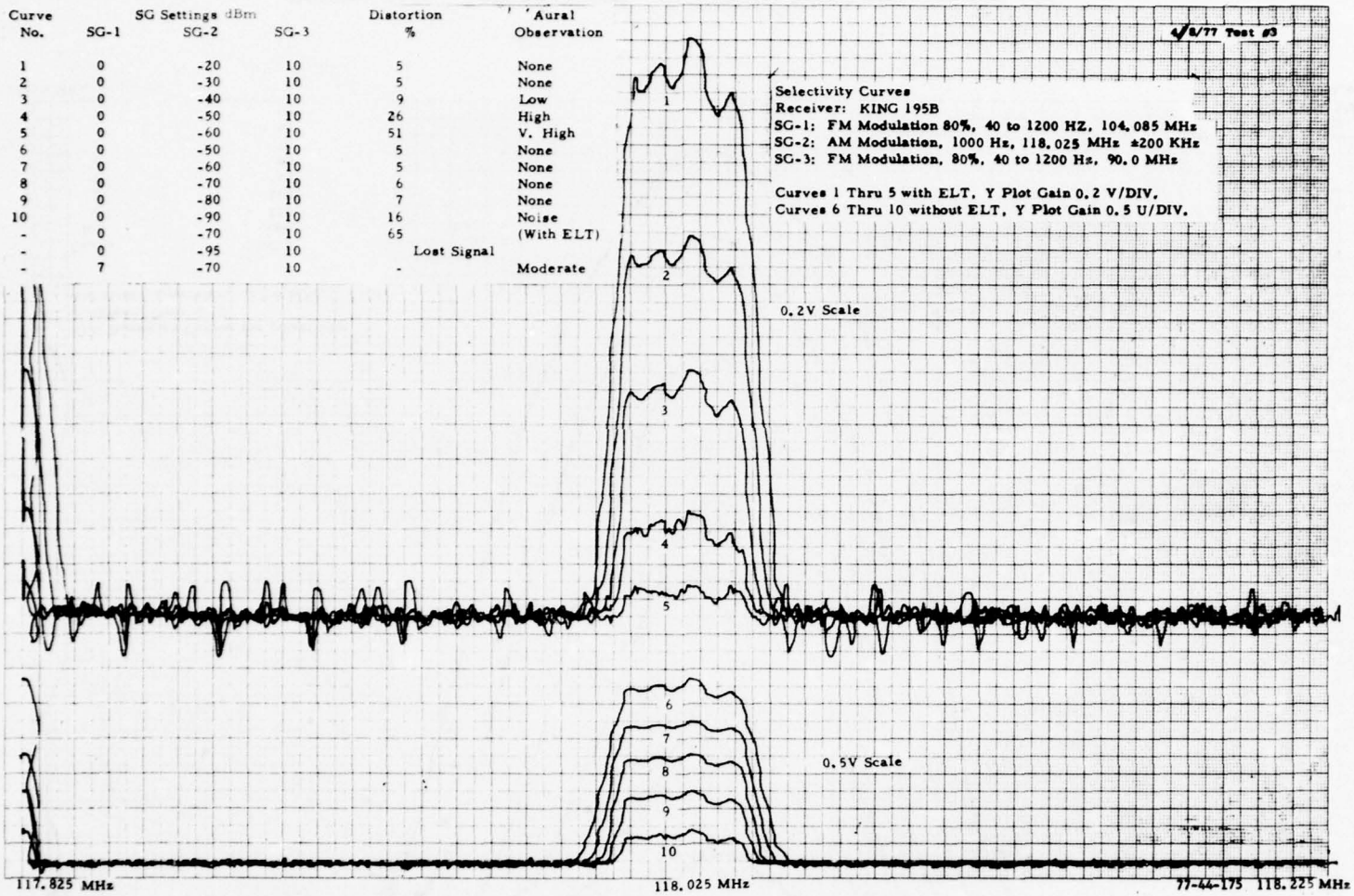


FIGURE 175. SELECTIVITY, MULTIPLE 3, DISTORTION TEST 3 KING 195B

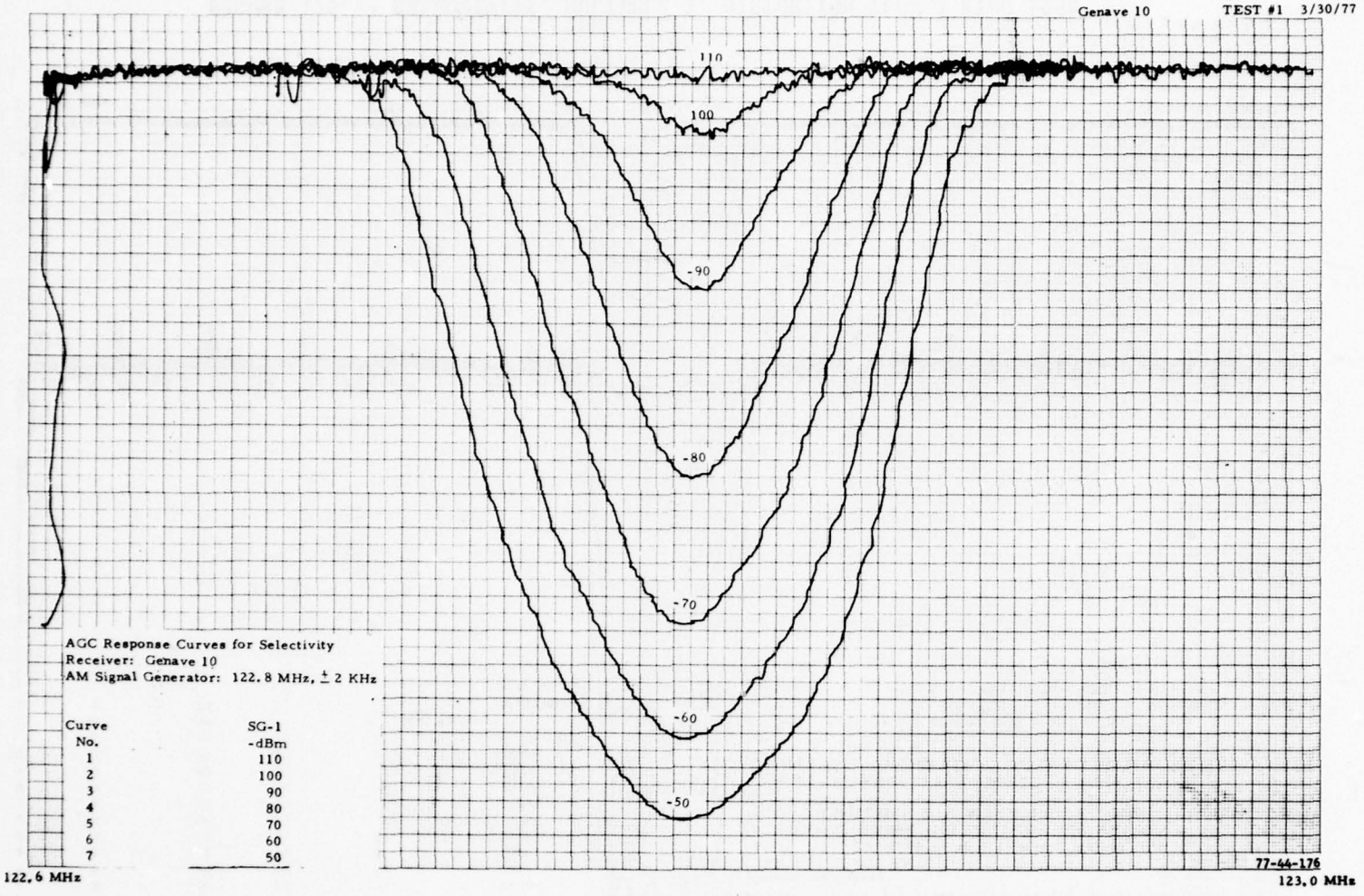


FIGURE 176. SELECTIVITY, AM SIGNAL 122.8 MHz GENAVE 10

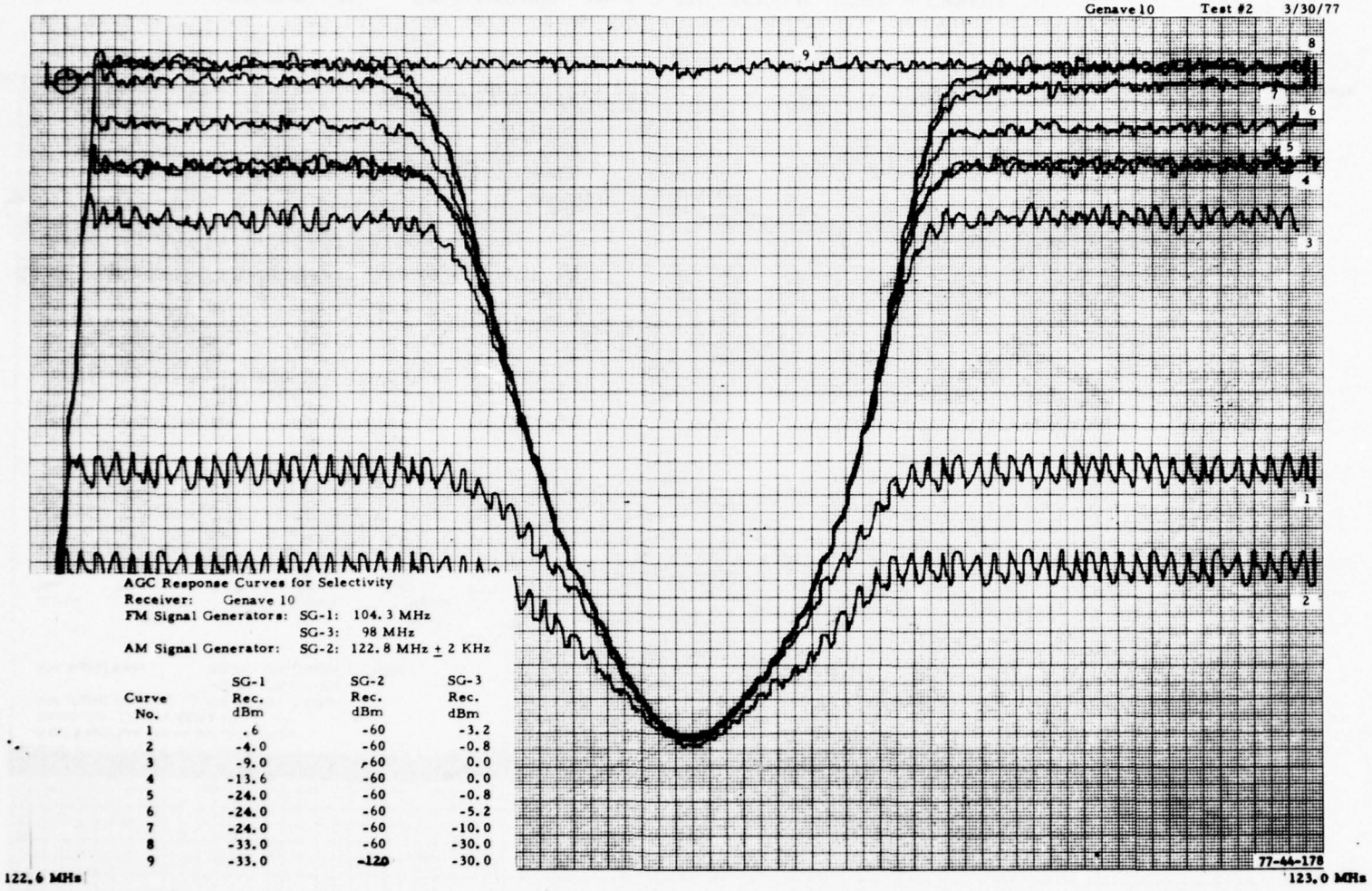
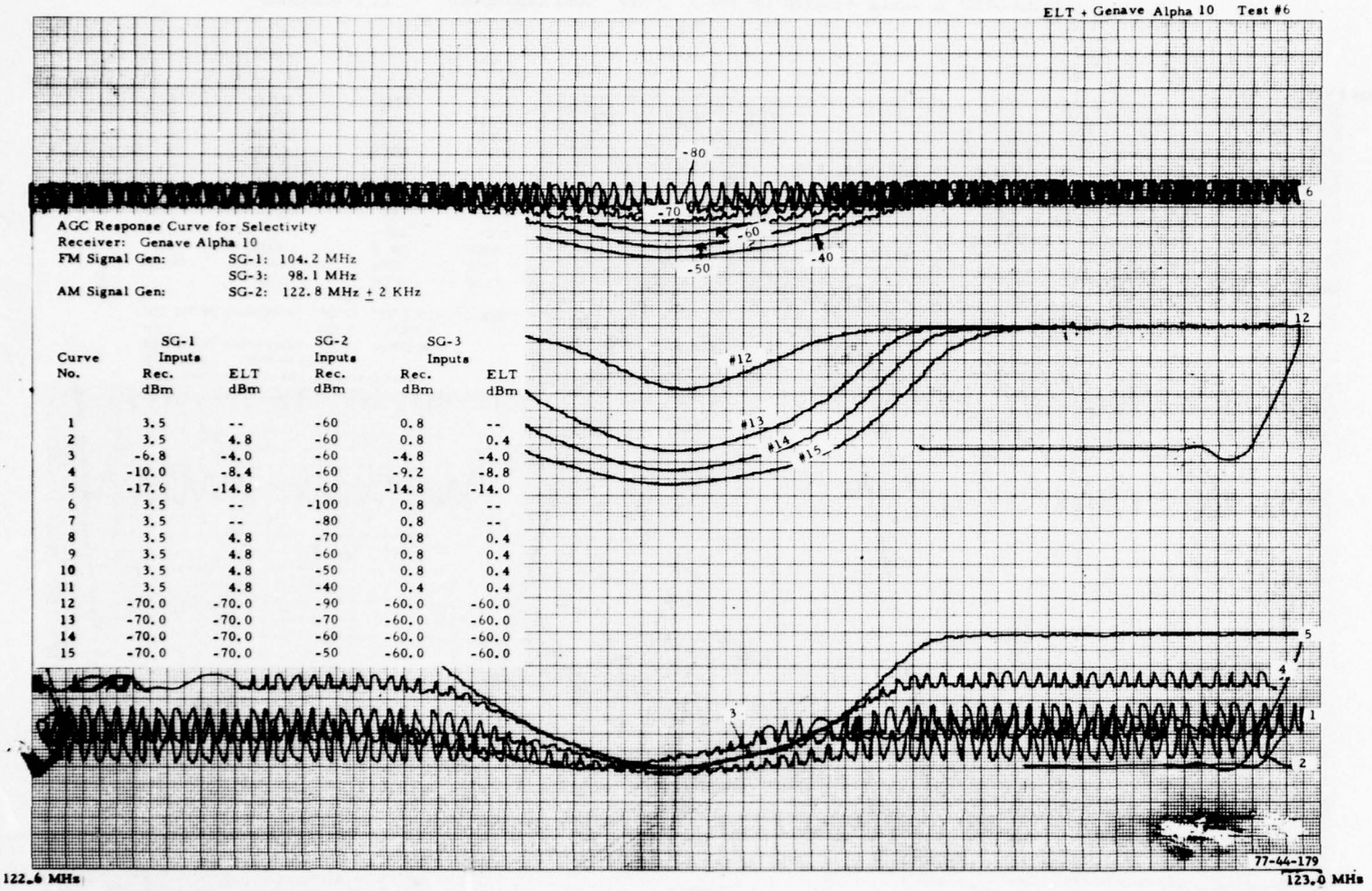


FIGURE 177. SELECTIVITY, AM & 2 FM SIGNALS, TEST 2 GENAVE 10



Curve No.	SG-1 Inputs Rec. dBm	ELT dBm	SG-2 Inputs Rec. dBm	SG-3 Inputs Rec. dBm	ELT dBm
1	3.5	--	-60	0.8	--
2	3.5	4.8	-60	0.8	0.4
3	-6.8	-4.0	-60	-4.8	-4.0
4	-10.0	-8.4	-60	-9.2	-8.8
5	-17.6	-14.8	-60	-14.8	-14.0
6	3.5	--	-100	0.8	--
7	3.5	--	-80	0.8	--
8	3.5	4.8	-70	0.8	0.4
9	3.5	4.8	-60	0.8	0.4
10	3.5	4.8	-50	0.8	0.4
11	3.5	4.8	-40	0.4	0.4
12	-70.0	-70.0	-90	-60.0	-60.0
13	-70.0	-70.0	-70	-60.0	-60.0
14	-70.0	-70.0	-60	-60.0	-60.0
15	-70.0	-70.0	-50	-60.0	-60.0

FIGURE 178. SELECTIVITY, AM & 2 FM SIGNALS, TEST 6 GENAVE 10

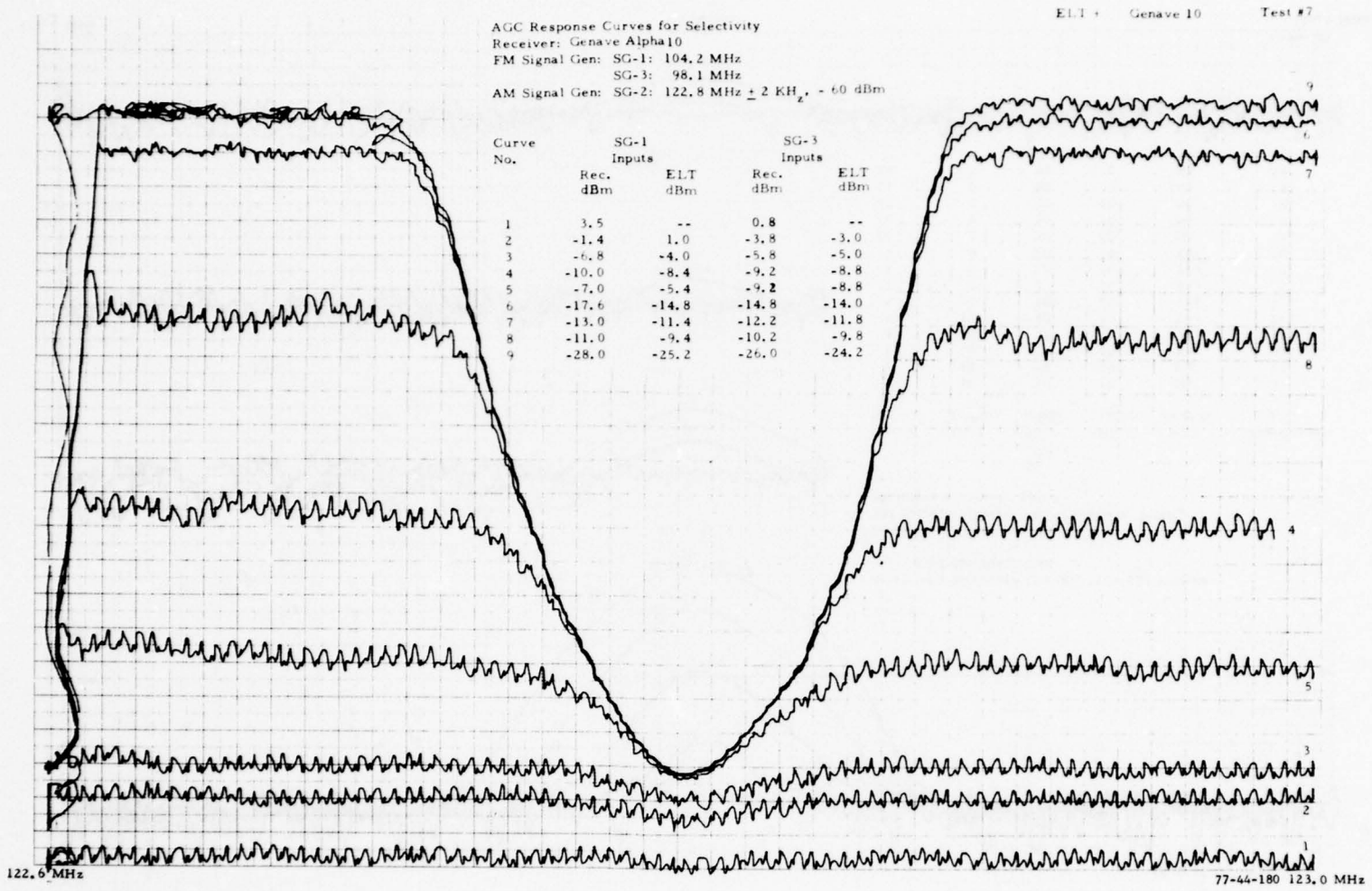
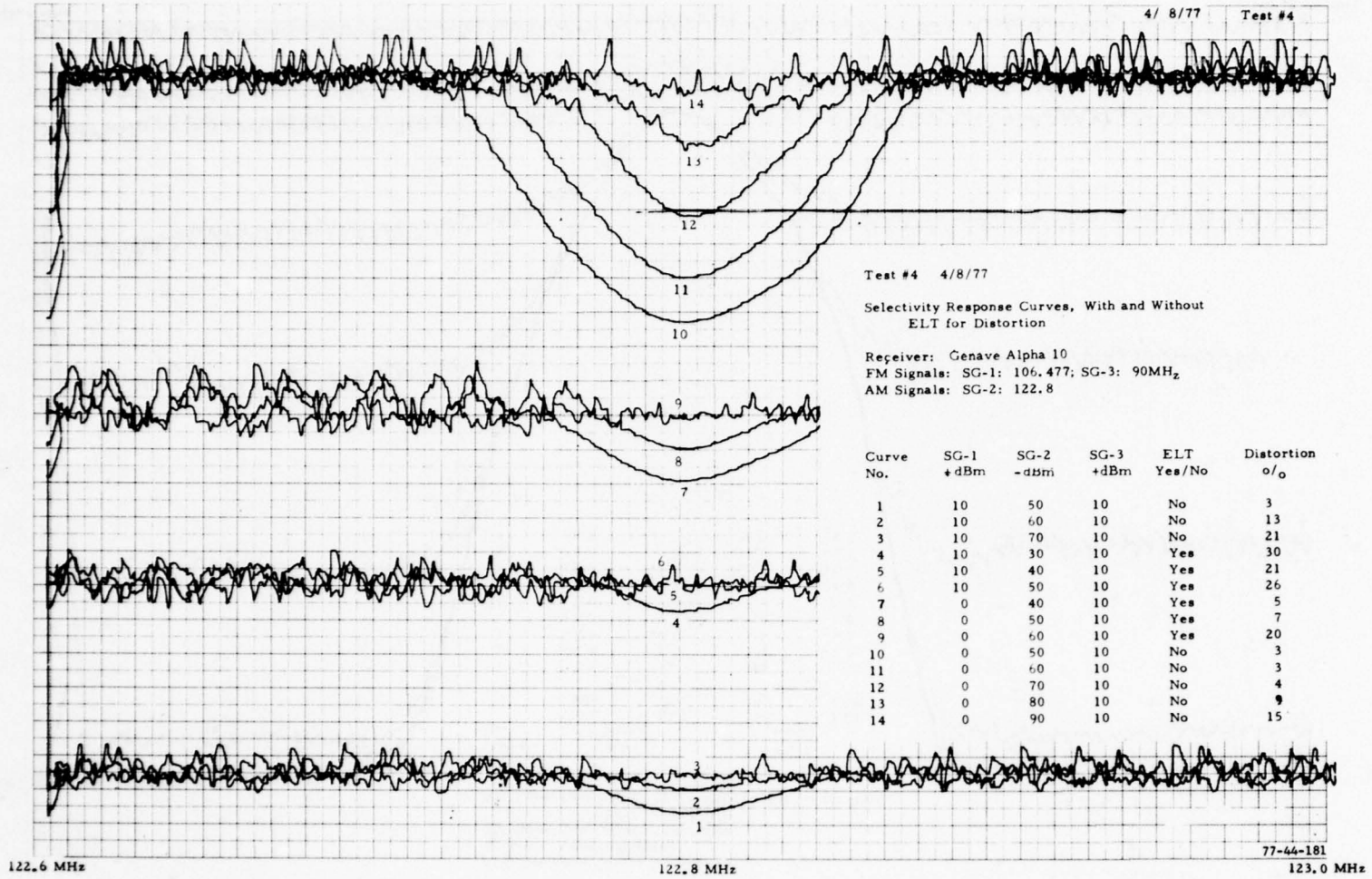


FIGURE 179. SELECTIVITY, AM & 2 FM SIGNALS, TEST 7 GENAVE 10



Curve No.	SG-1 +dBm	SG-2 -dBm	SG-3 +dBm	ELT Yes/No	Distortion o/o
1	10	50	10	No	3
2	10	60	10	No	13
3	10	70	10	No	21
4	10	30	10	Yes	30
5	10	40	10	Yes	21
6	10	50	10	Yes	26
7	0	40	10	Yes	5
8	0	50	10	Yes	7
9	0	60	10	Yes	20
10	0	50	10	No	3
11	0	60	10	No	3
12	0	70	10	No	4
13	0	80	10	No	9
14	0	90	10	No	15

FIGURE 180. SELECTIVITY, DISTORTION TEST 4 GENAVE 10

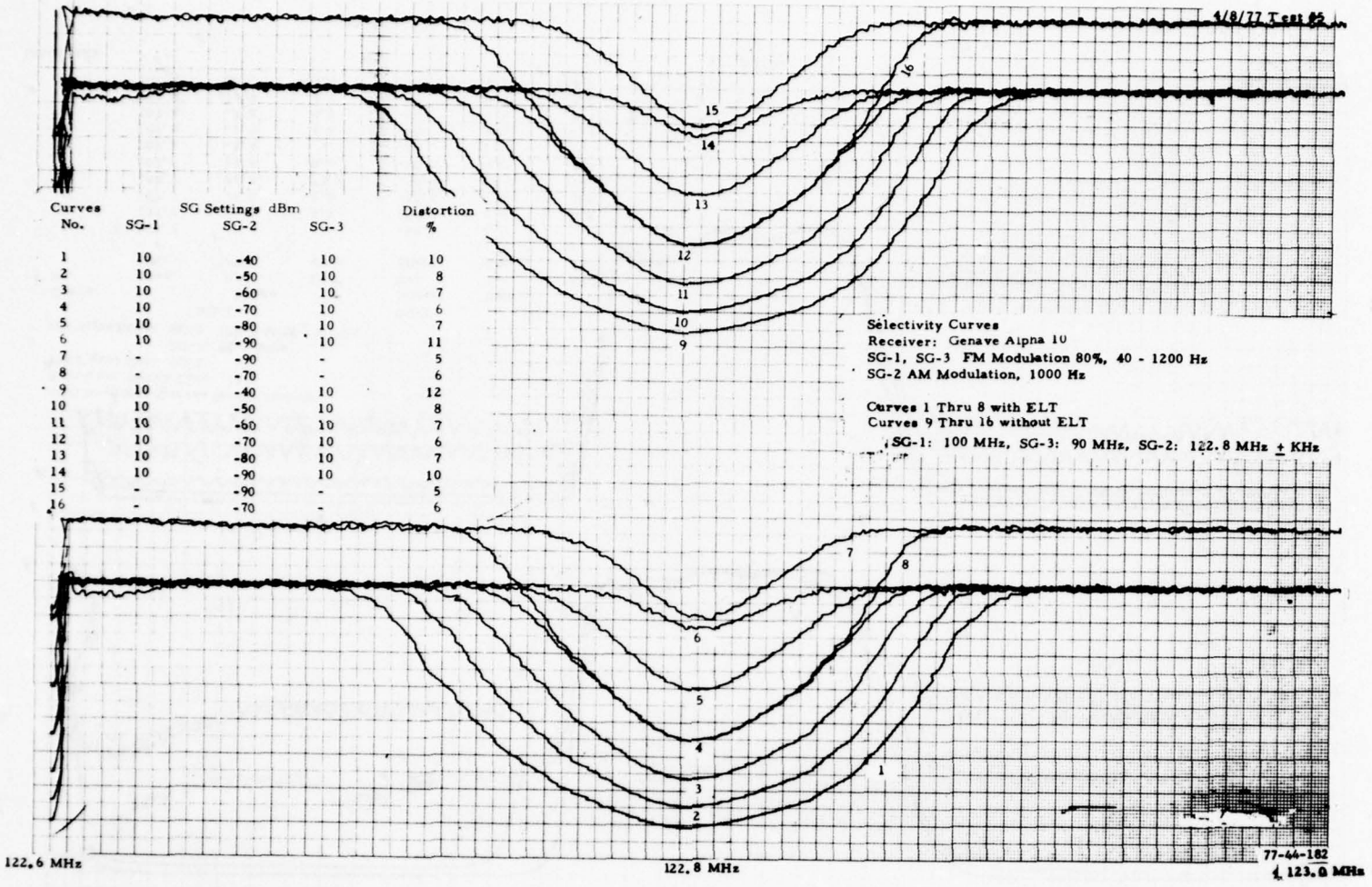
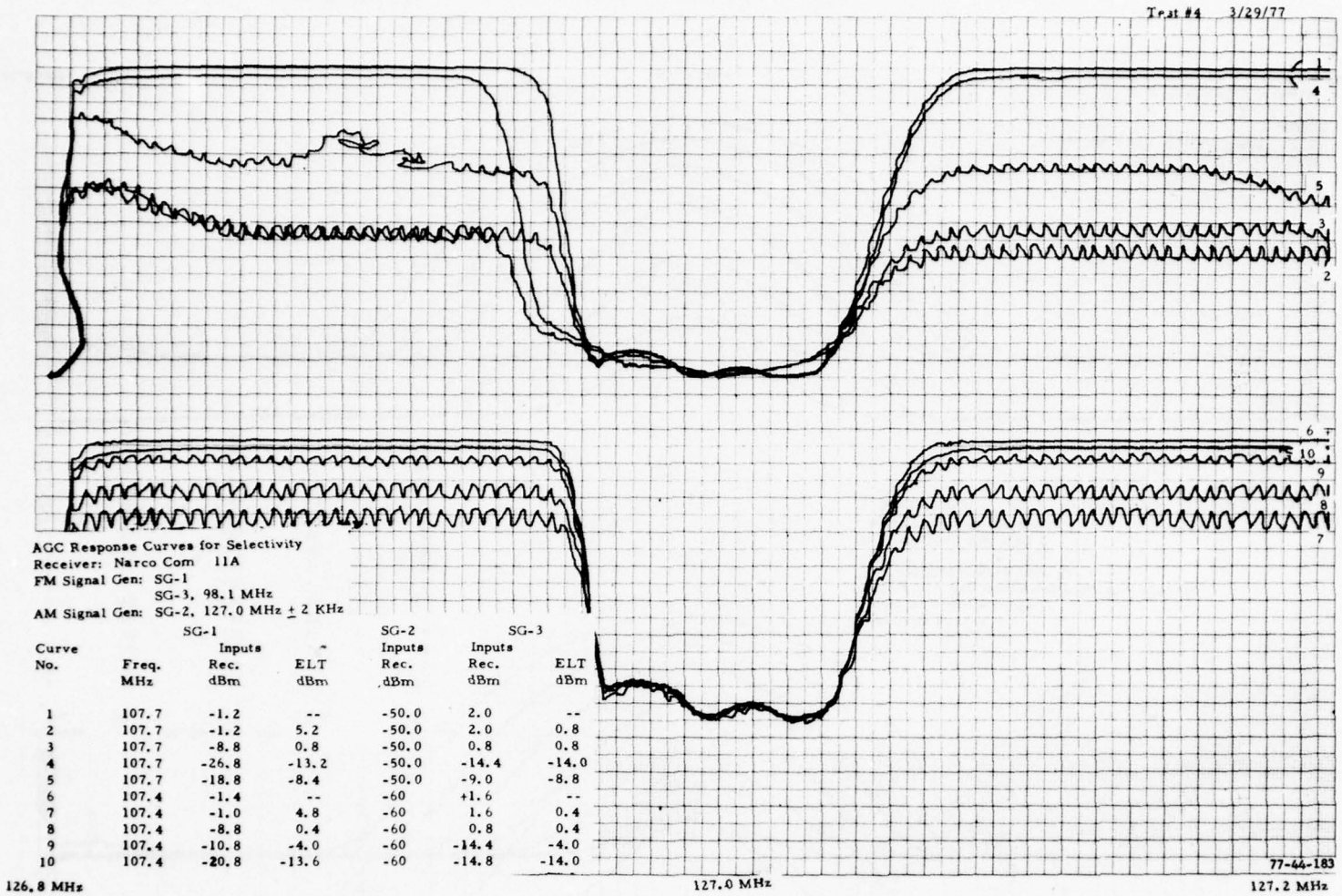


FIGURE 181. SELECTIVITY, DISTORTION TEST 5 GENAVE 10



AGC Response Curves for Selectivity
Receiver: Narco Com 11A
FM Signal Gen: SG-1
SG-3, 98.1 MHz
AM Signal Gen: SG-2, 127.0 MHz ± 2 KHz

Curve No.	Freq. MHz	SG-1 Inputs Rec. dBm	SG-1 Inputs ELT dBm	SG-2 Inputs Rec. dBm	SG-3 Inputs Rec. dBm	SG-3 Inputs ELT dBm
1	107.7	-1.2	--	-50.0	2.0	--
2	107.7	-1.2	5.2	-50.0	2.0	0.8
3	107.7	-8.8	0.8	-50.0	0.8	0.8
4	107.7	-26.8	-13.2	-50.0	-14.4	-14.0
5	107.7	-18.8	-8.4	-50.0	-9.0	-8.8
6	107.4	-1.4	--	-60	+1.6	--
7	107.4	-1.0	4.8	-60	1.6	0.4
8	107.4	-8.8	0.4	-60	0.8	0.4
9	107.4	-10.8	-4.0	-60	-14.4	-4.0
10	107.4	-20.8	-13.6	-60	-14.8	-14.0

FIGURE 182. SELECTIVITY, AM & 2 FM SIGNALS TEST 4 COM 11A

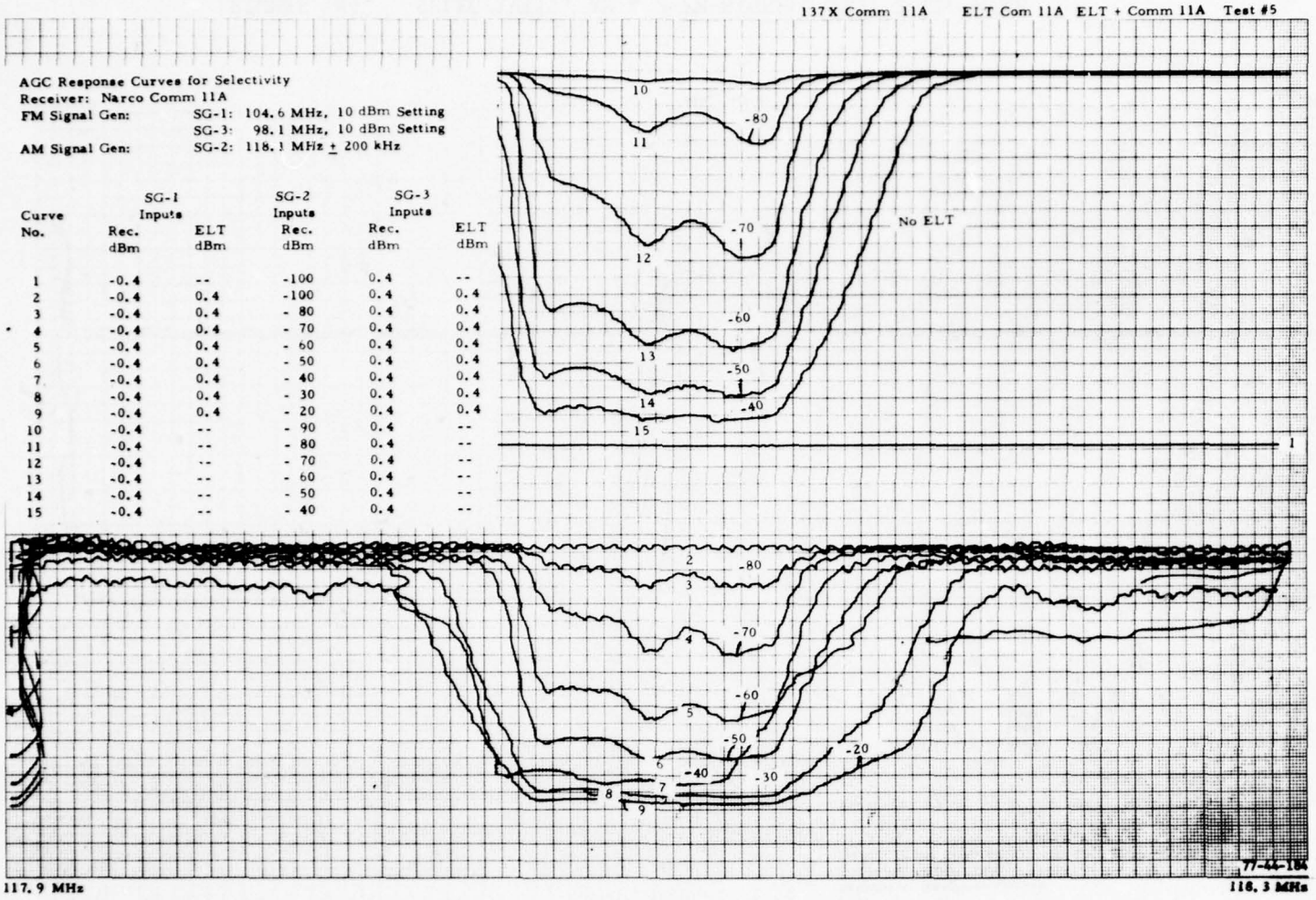


FIGURE 183. SELECTIVITY, AM & 2 FM SIGNALS TEST 5 COM 11A

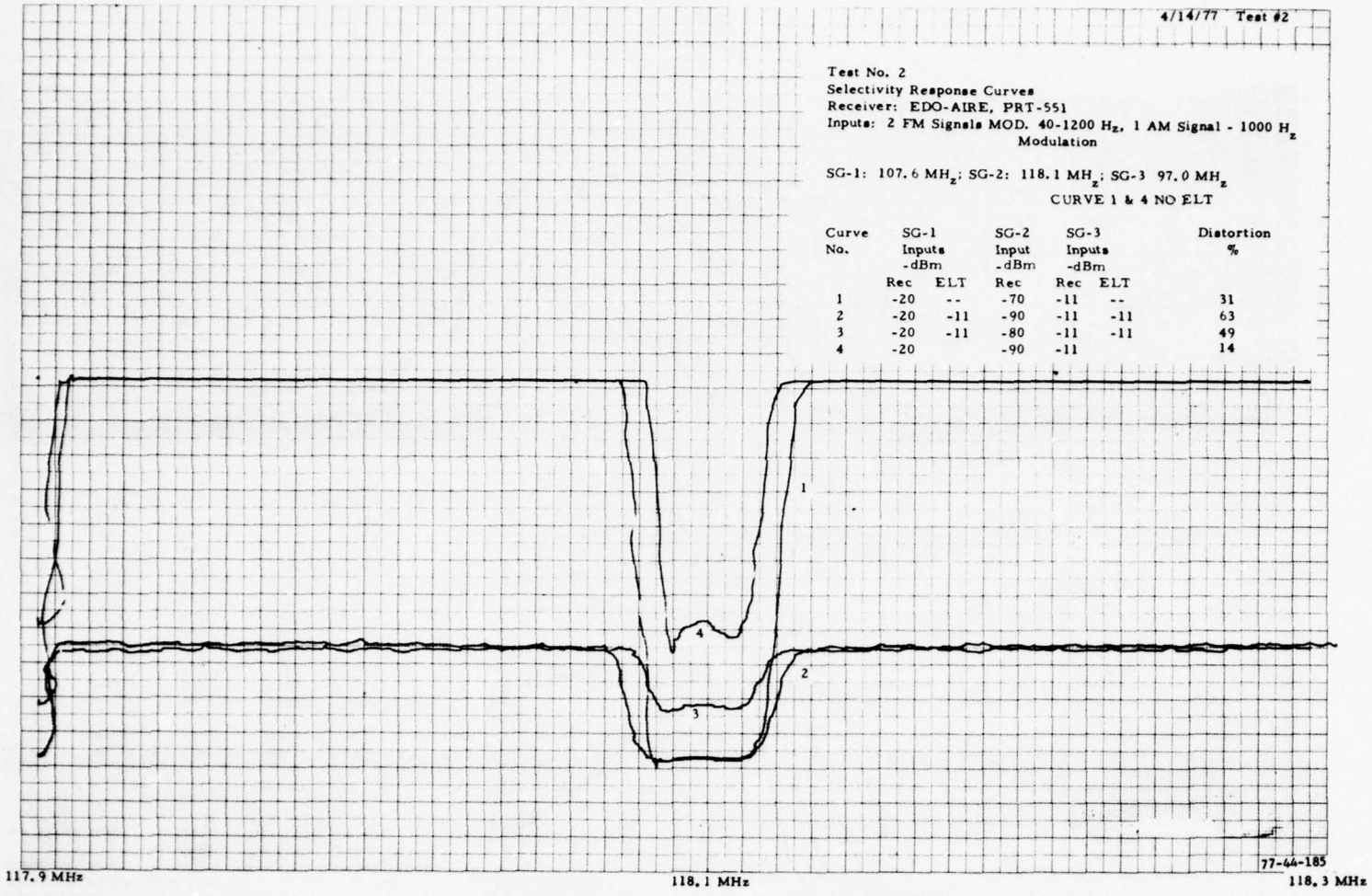


FIGURE 184. SELECTIVITY, AM & 2 FM SIGNALS TEST 2 EDO-AIRE

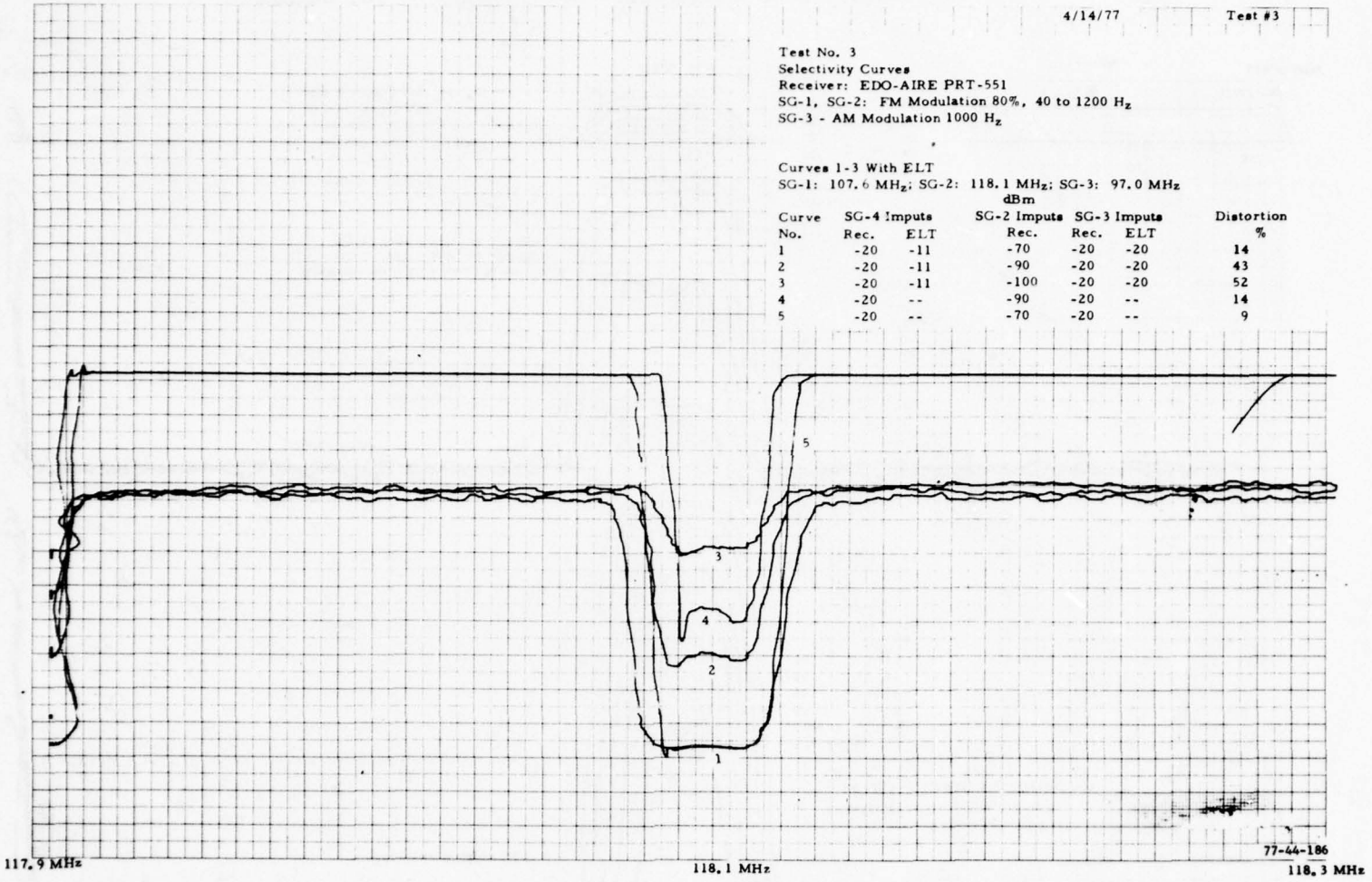


FIGURE 185. SELECTIVITY, AM & 2 FM SIGNALS TEST 3 EDO-AIRE

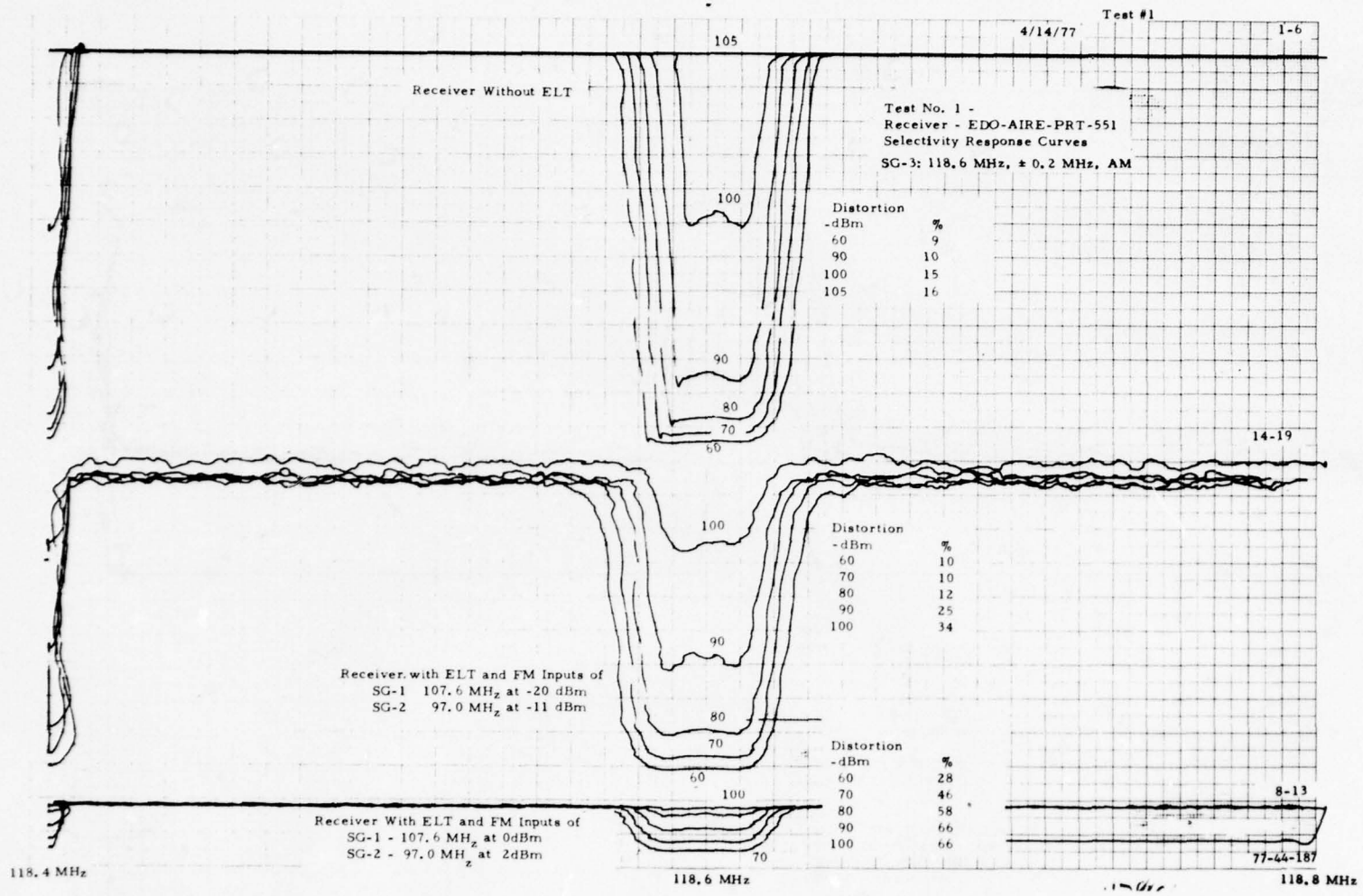
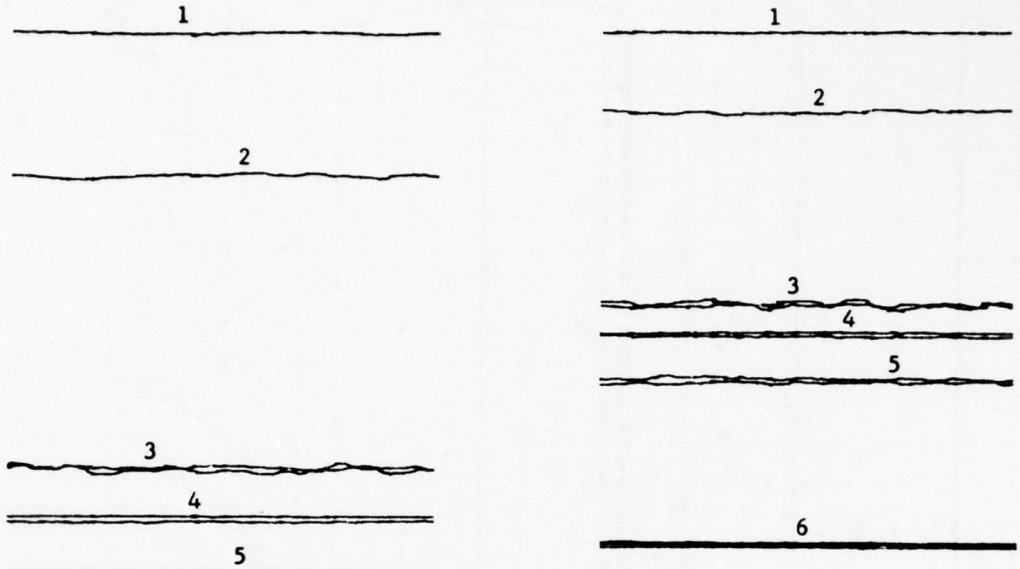
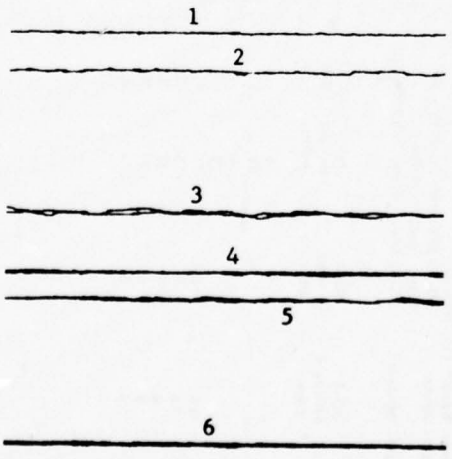


FIGURE 186. SELECTIVITY, DISTORTION TEST 1 EDO-AIRE





LEGEND
FM SIGNAL dBm (AM SIGNAL dBm)

1. (-85) dBm
2. -20(-85)
3. -10(-85), 0(-85)
4. -(-75)
5. -20(-75), -10(-75), 0(-75)
6. (-65), -20(-65), -10(-65), 0(-65)

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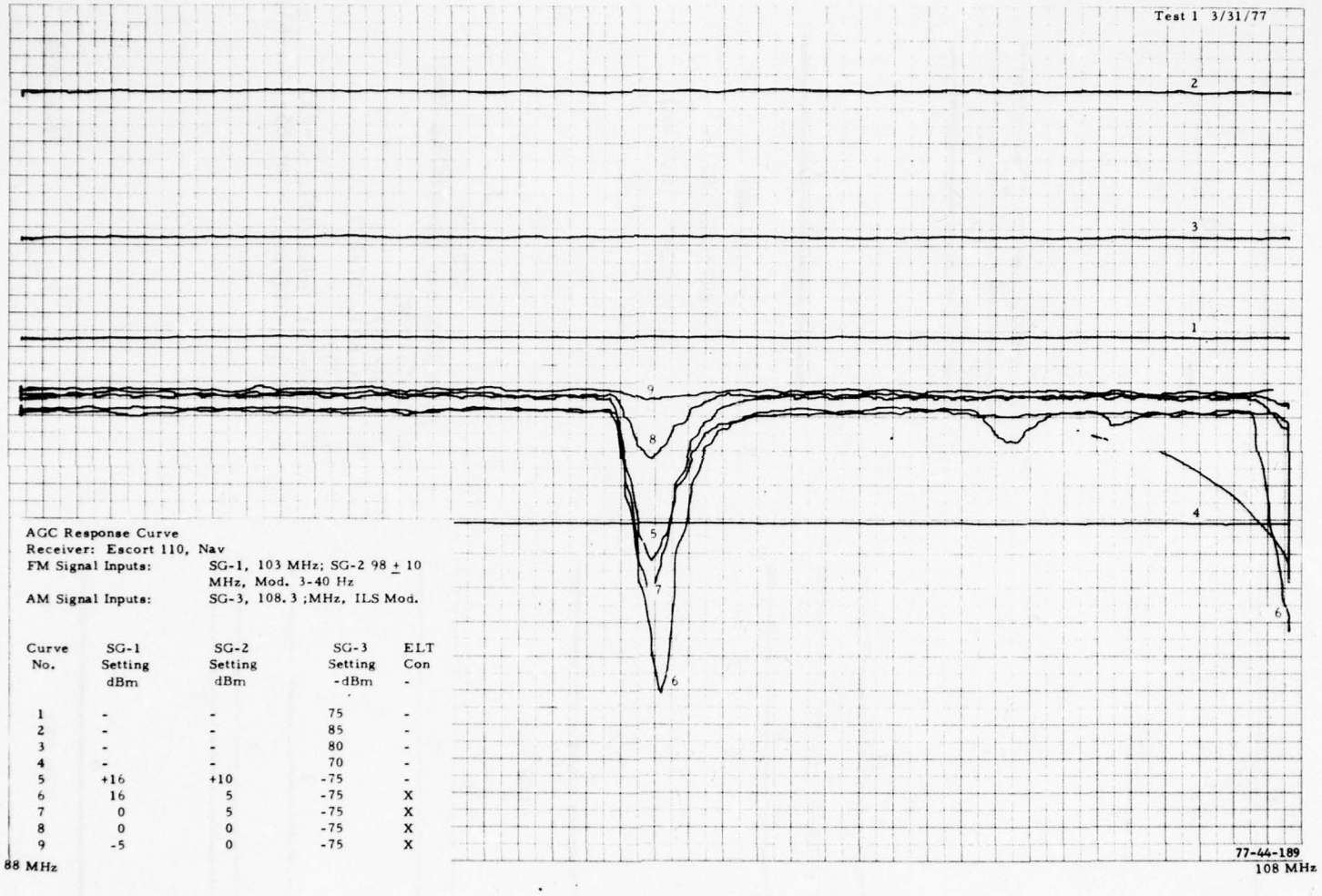
FIGURE 187. AGC RESPONSE, AM & FM SIGNALS ESCORT 110



AGC Response Curve
Receiver: Escort 110, Nav
FM Signal Inputs: SG-1, 103 MHz; SG-2 98 ± 10 MHz, Mod. 3-40 Hz
AM Signal Inputs: SG-3, 108.3 ;MHz, ILS Mod.

Curve No.	SG-1 Setting dBm	SG-2 Setting dBm	SG-3 Setting -dBm	ELT Con -
1	-	-	75	-
2	-	-	85	-
3	-	-	80	-
4	-	-	70	-
5	+16	+10	-75	-
6	16	5	-75	X
7	0	5	-75	X
8	0	0	-75	X
9	-5	0	-75	X

FIGURE 188. INTERMODULATION TEST 1, 2 FM SIGNALS ESCORT 110

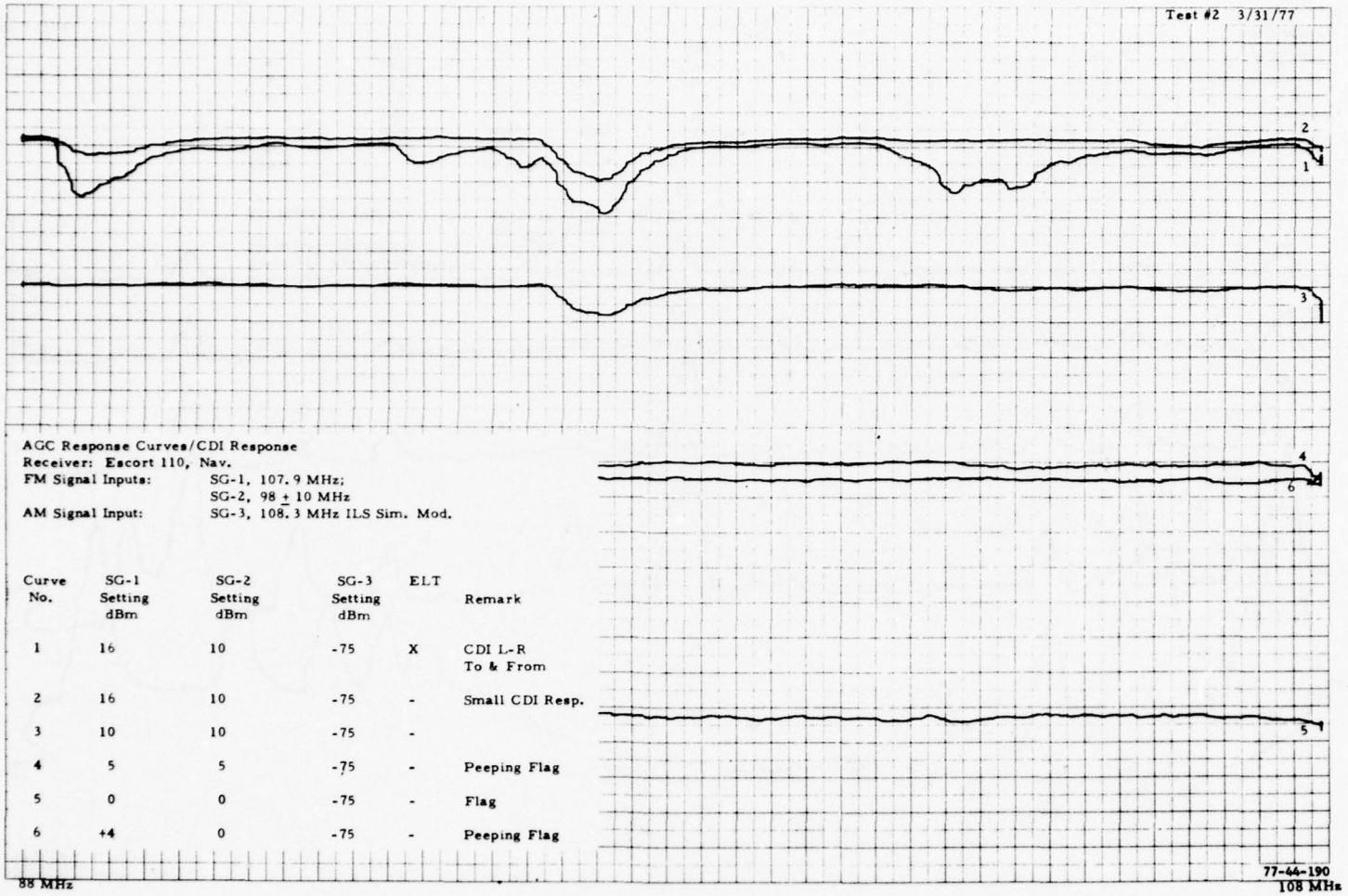


FIGURE 189. INTERMODULATION TEST 2, 2 FM SIGNALS ESCORT 110

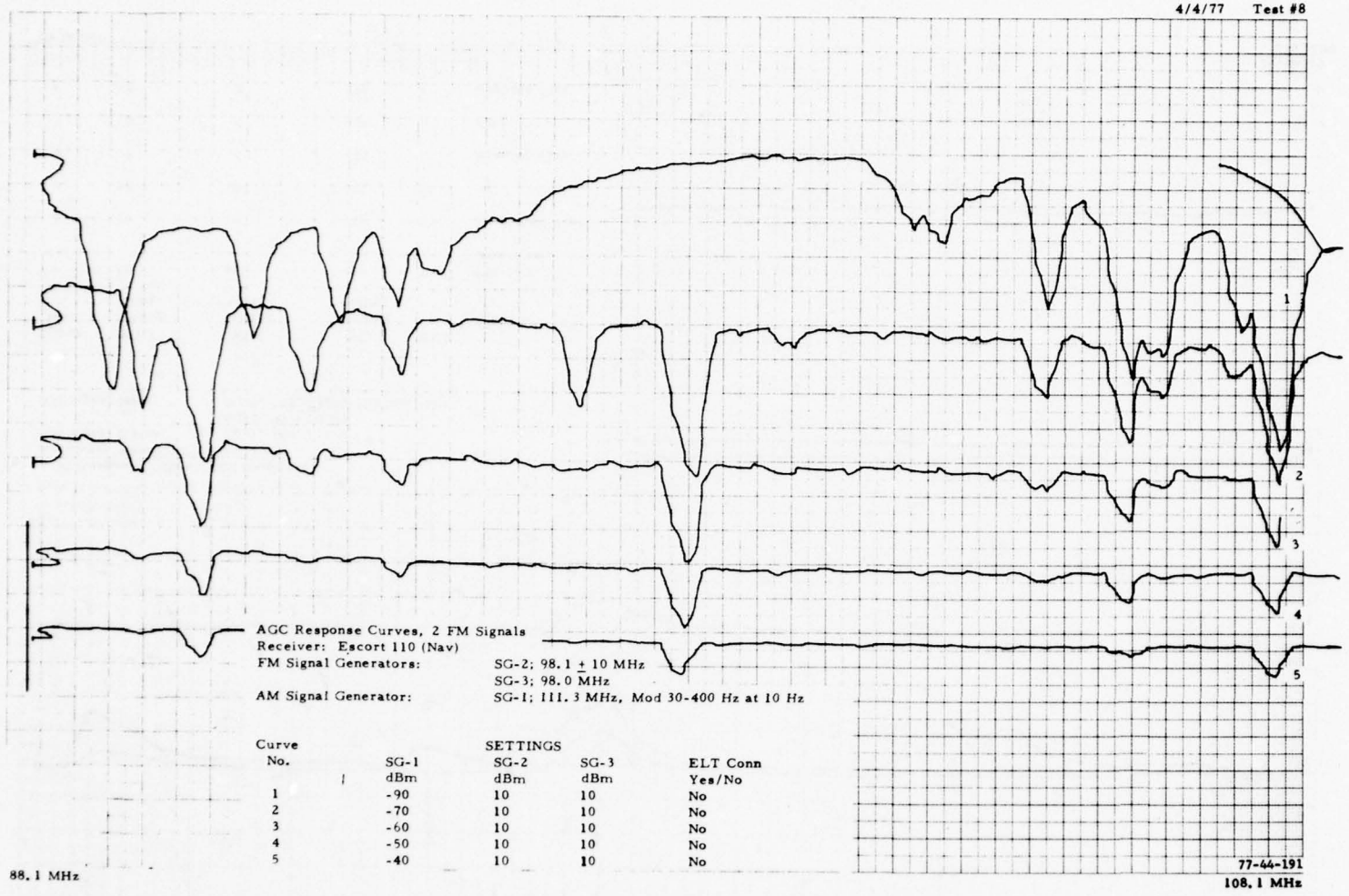


FIGURE 190. INTERMODULATION TEST 8, 2 FM SIGNALS ESCORT 110

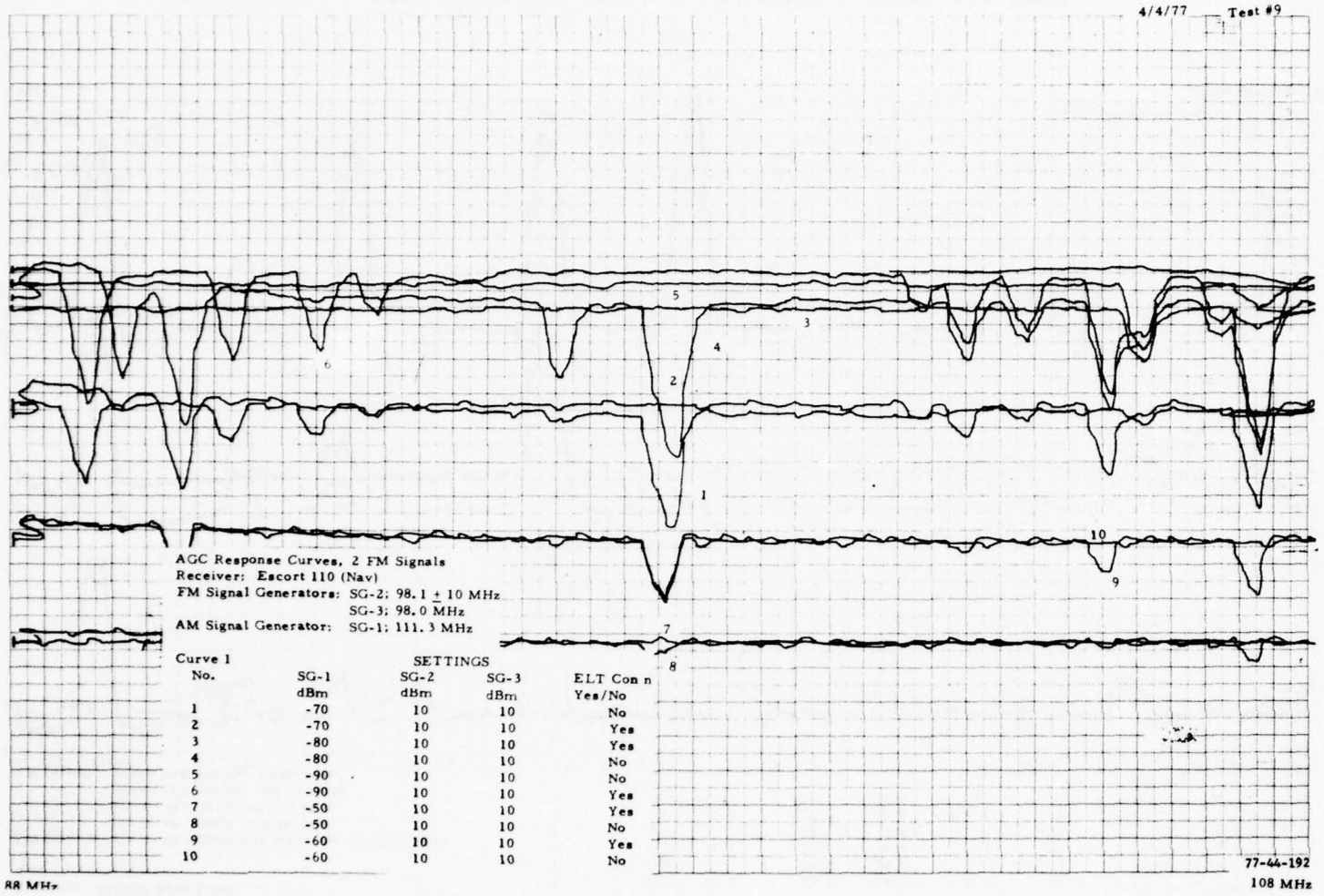


FIGURE 191. INTERMODULATION TEST 2, 2 FM SIGNALS ESCORT 110

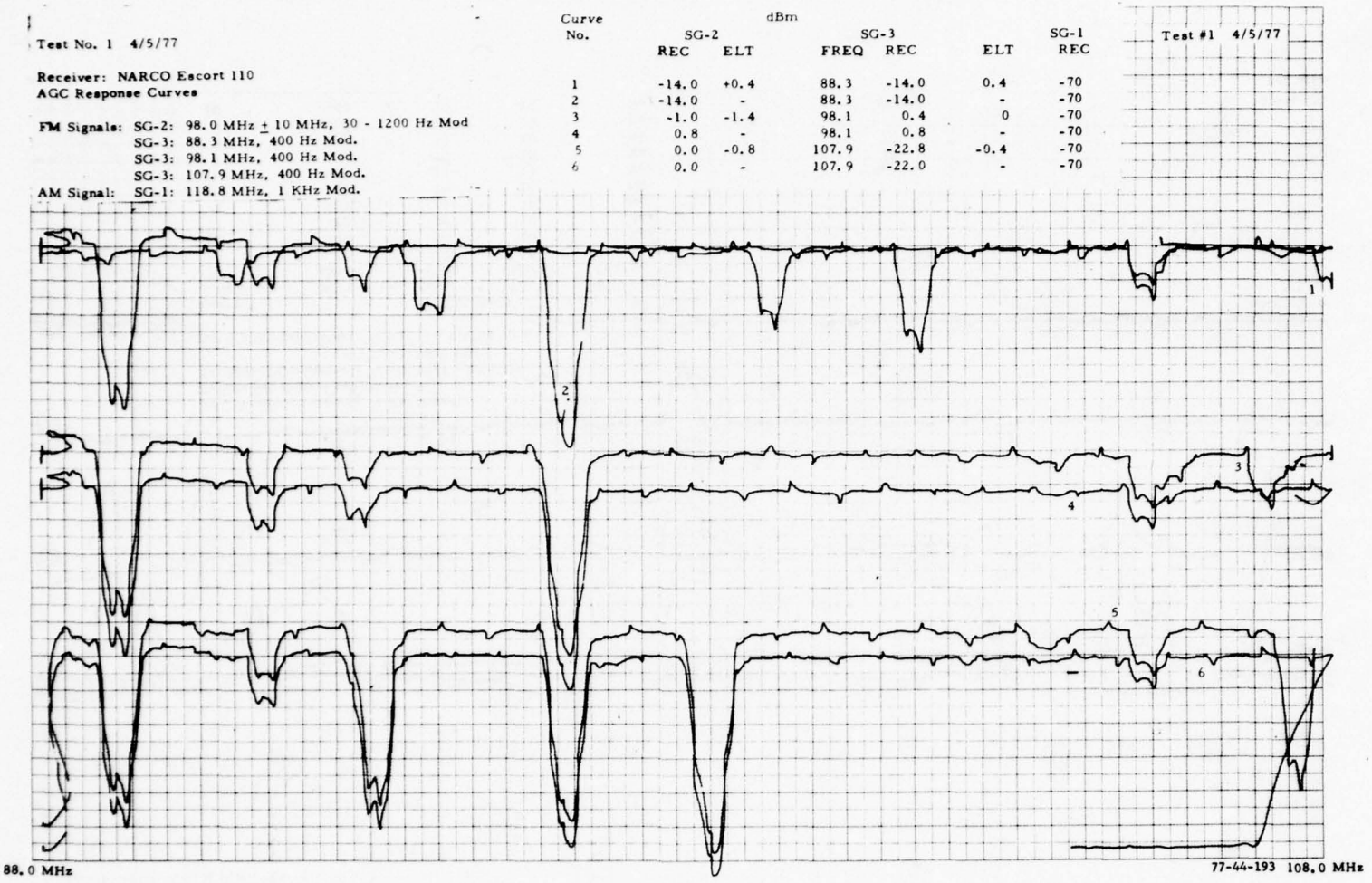
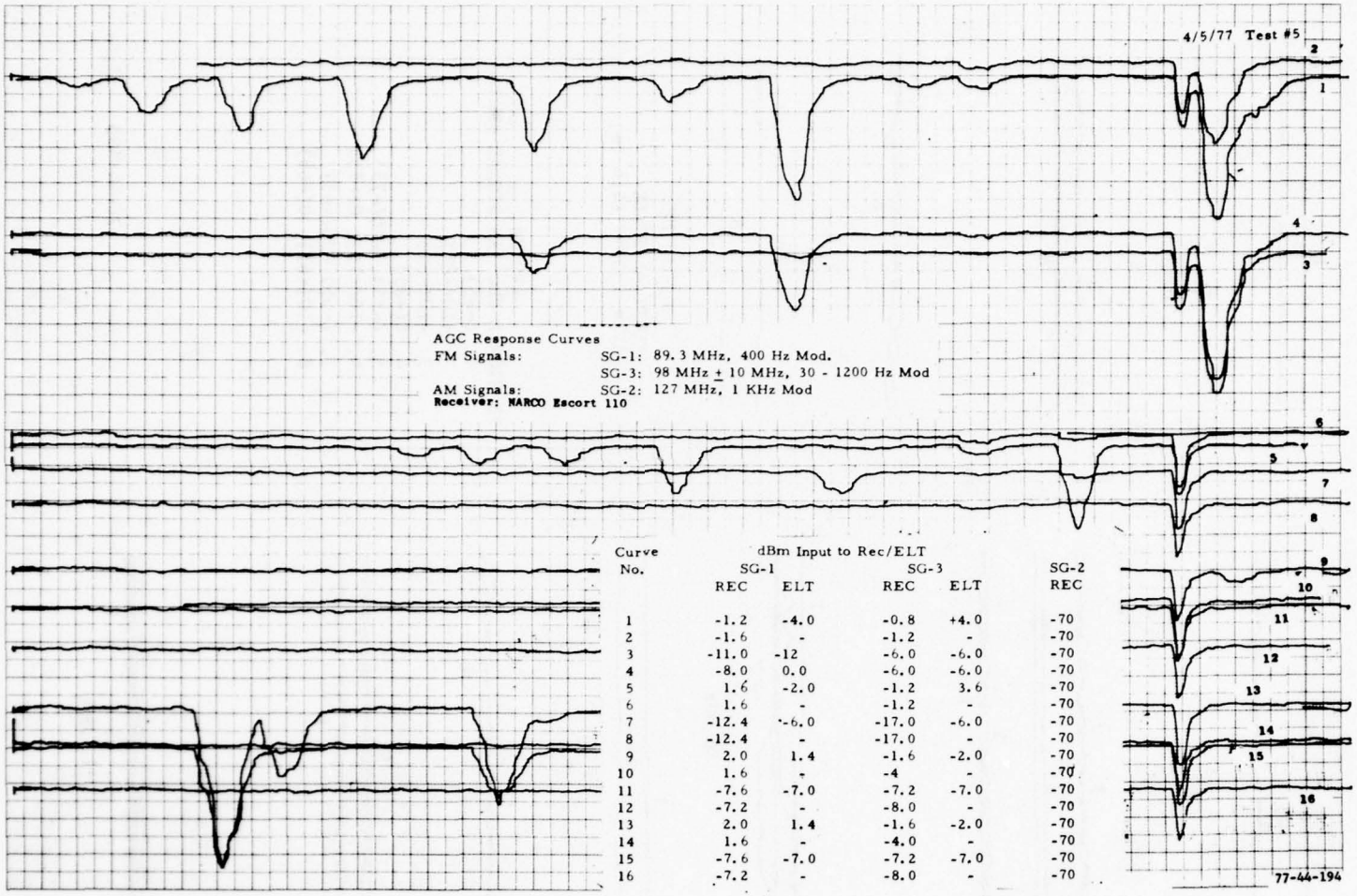


FIGURE 192. INTERMODULATION TEST 1, 2 FM SIGNALS ESCORT 110 (COM)



Curve No.	dBm Input to Rec/ELT SG-1 REC	SG-1 ELT	SG-3 REC	SG-3 ELT	SG-2 REC
1	-1.2	-4.0	-0.8	+4.0	-70
2	-1.6	-	-1.2	-	-70
3	-11.0	-12	-6.0	-6.0	-70
4	-8.0	0.0	-6.0	-6.0	-70
5	1.6	-2.0	-1.2	3.6	-70
6	1.6	-	-1.2	-	-70
7	-12.4	-6.0	-17.0	-6.0	-70
8	-12.4	-	-17.0	-	-70
9	2.0	1.4	-1.6	-2.0	-70
10	1.6	-	-4	-	-70
11	-7.6	-7.0	-7.2	-7.0	-70
12	-7.2	-	-8.0	-	-70
13	2.0	1.4	-1.6	-2.0	-70
14	1.6	-	-4.0	-	-70
15	-7.6	-7.0	-7.2	-7.0	-70
16	-7.2	-	-8.0	-	-70

FIGURE 193. INTERMODULATION TEST 5, 2 FM SIGNALS ESCORT 110 (COM)

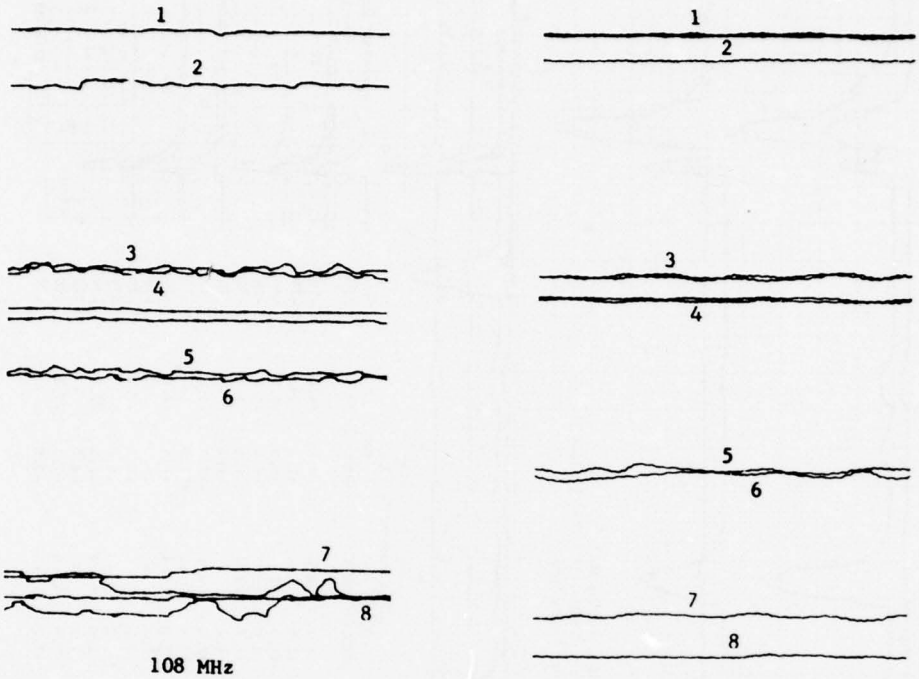
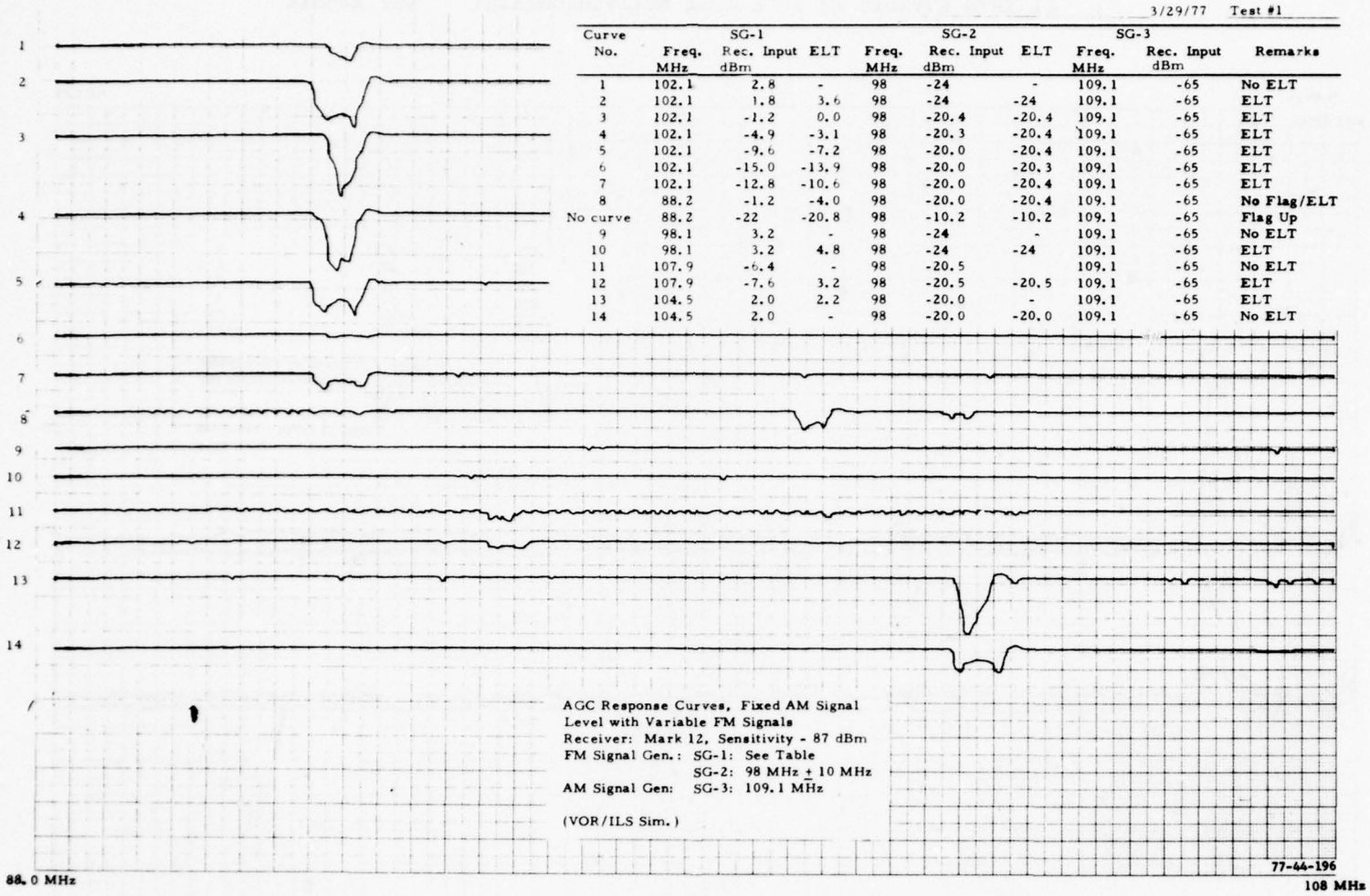


FIGURE 194. AGC RESPONSE, AM & FM SIGNALS MARK 12



Curve No.	SG-1 Freq. MHz	SG-1 Rec. Input dBm	SG-1 ELT	SG-2 Freq. MHz	SG-2 Rec. Input dBm	SG-2 ELT	SG-3 Freq. MHz	SG-3 Rec. Input dBm	Remarks
1	102.1	2.8	-	98	-24	-	109.1	-65	No ELT
2	102.1	1.8	3.6	98	-24	-24	109.1	-65	ELT
3	102.1	-1.2	0.0	98	-20.4	-20.4	109.1	-65	ELT
4	102.1	-4.9	-3.1	98	-20.3	-20.4	109.1	-65	ELT
5	102.1	-9.6	-7.2	98	-20.0	-20.4	109.1	-65	ELT
6	102.1	-15.0	-13.9	98	-20.0	-20.3	109.1	-65	ELT
7	102.1	-12.8	-10.6	98	-20.0	-20.4	109.1	-65	ELT
8	88.2	-1.2	-4.0	98	-20.0	-20.4	109.1	-65	No Flag/ELT
No curve	88.2	-22	-20.8	98	-10.2	-10.2	109.1	-65	Flag Up
9	98.1	3.2	-	98	-24	-	109.1	-65	No ELT
10	98.1	3.2	4.8	98	-24	-24	109.1	-65	ELT
11	107.9	-6.4	-	98	-20.5		109.1	-65	No ELT
12	107.9	-7.6	3.2	98	-20.5	-20.5	109.1	-65	ELT
13	104.5	2.0	2.2	98	-20.0	-	109.1	-65	ELT
14	104.5	2.0	-	98	-20.0	-20.0	109.1	-65	No ELT

FIGURE 195. INTERMODULATION TEST 1, 2 FM SIGNALS MARK 12

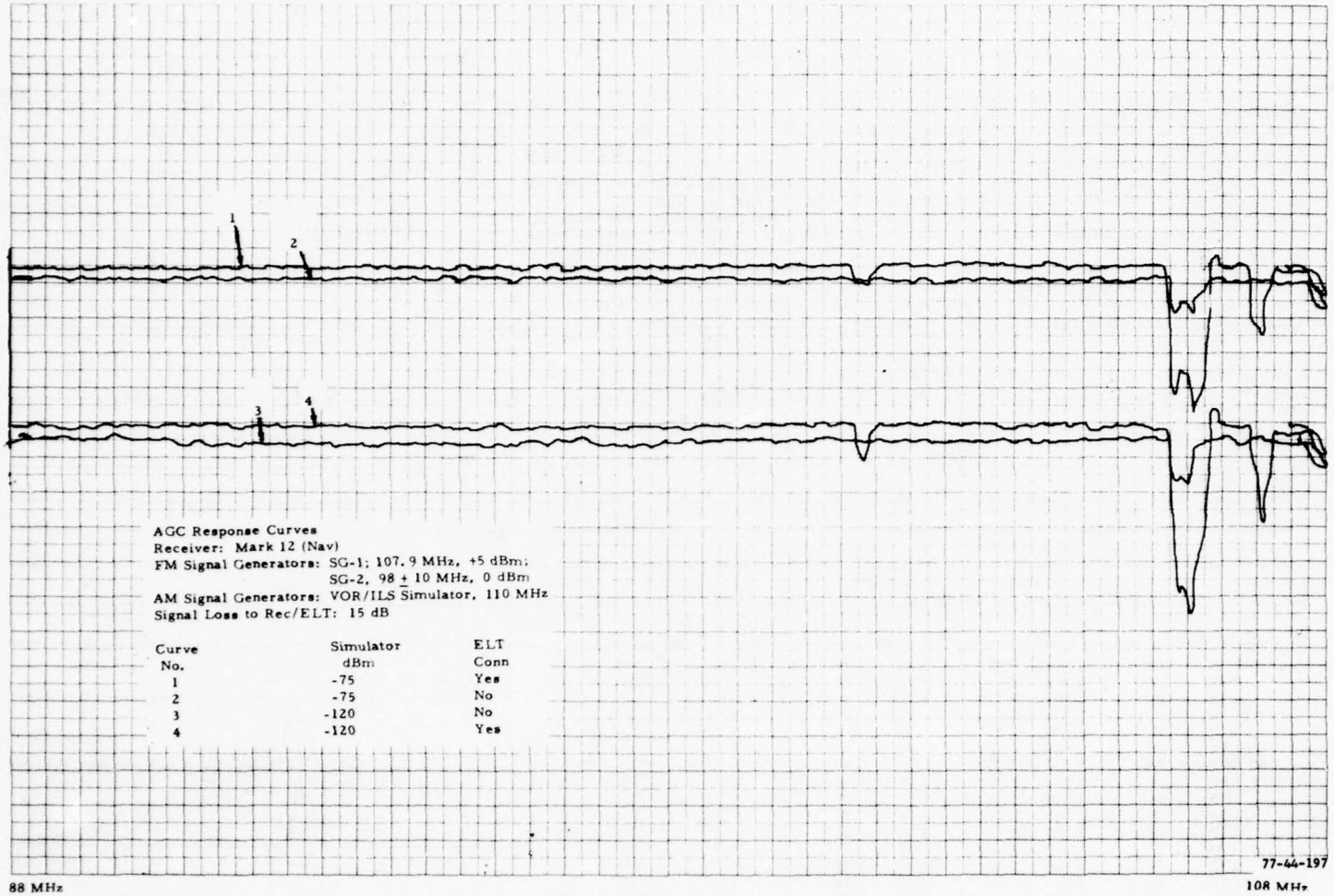


FIGURE 196. INTERMODULATION TEST 2, 2 FM SIGNALS MARK 12

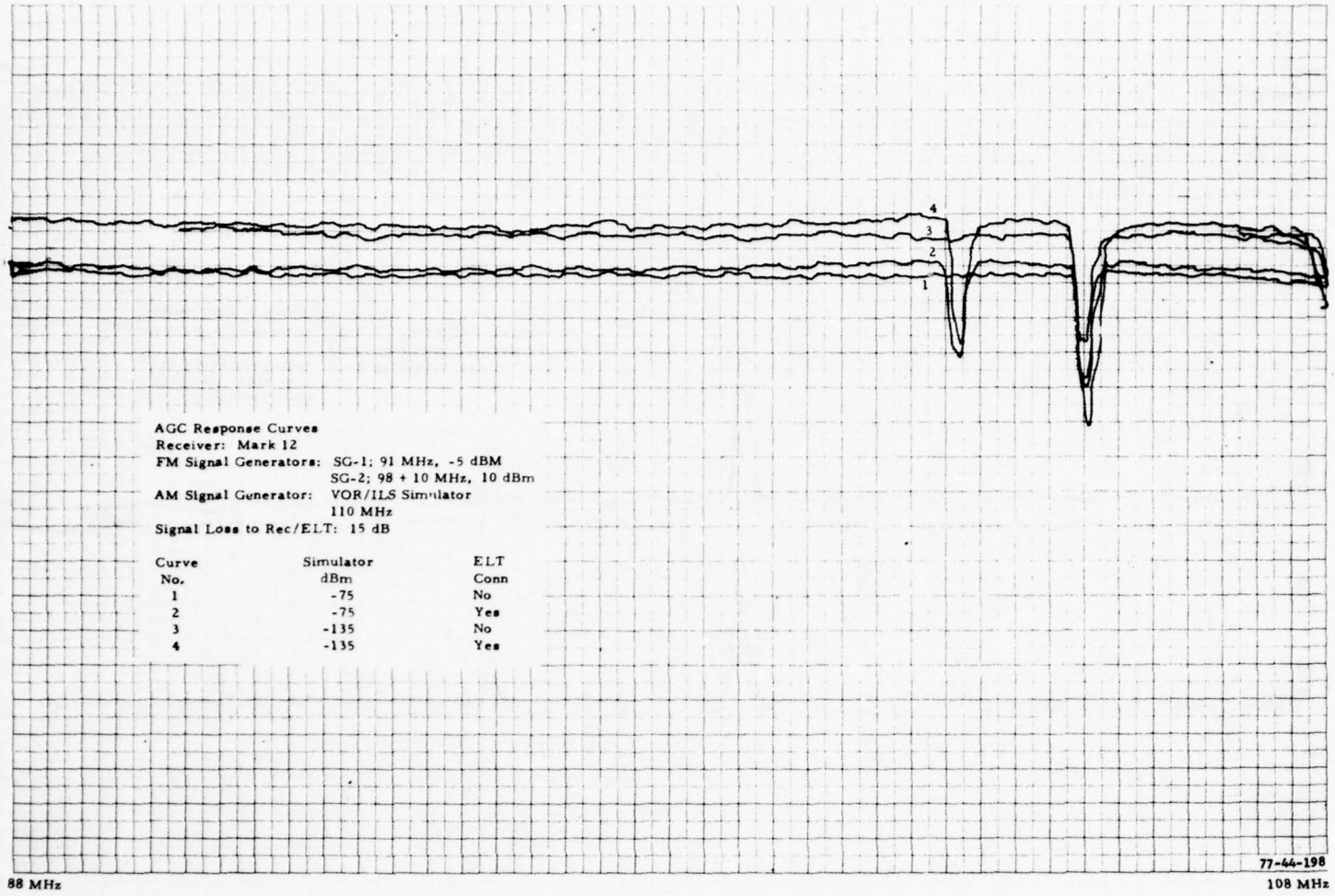


FIGURE 197. INTERMODULATION TEST 3, 2 FM SIGNALS MARK 12

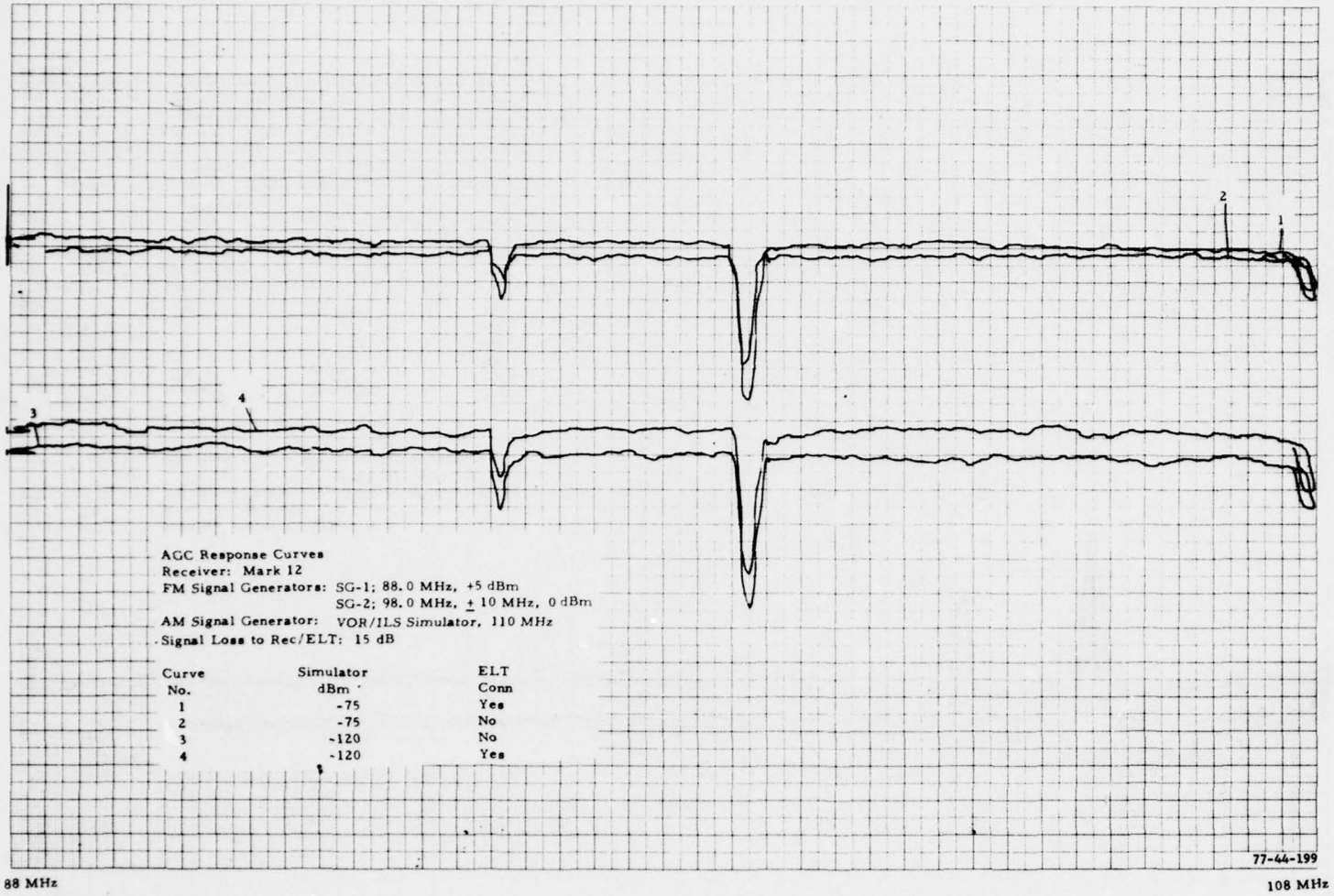
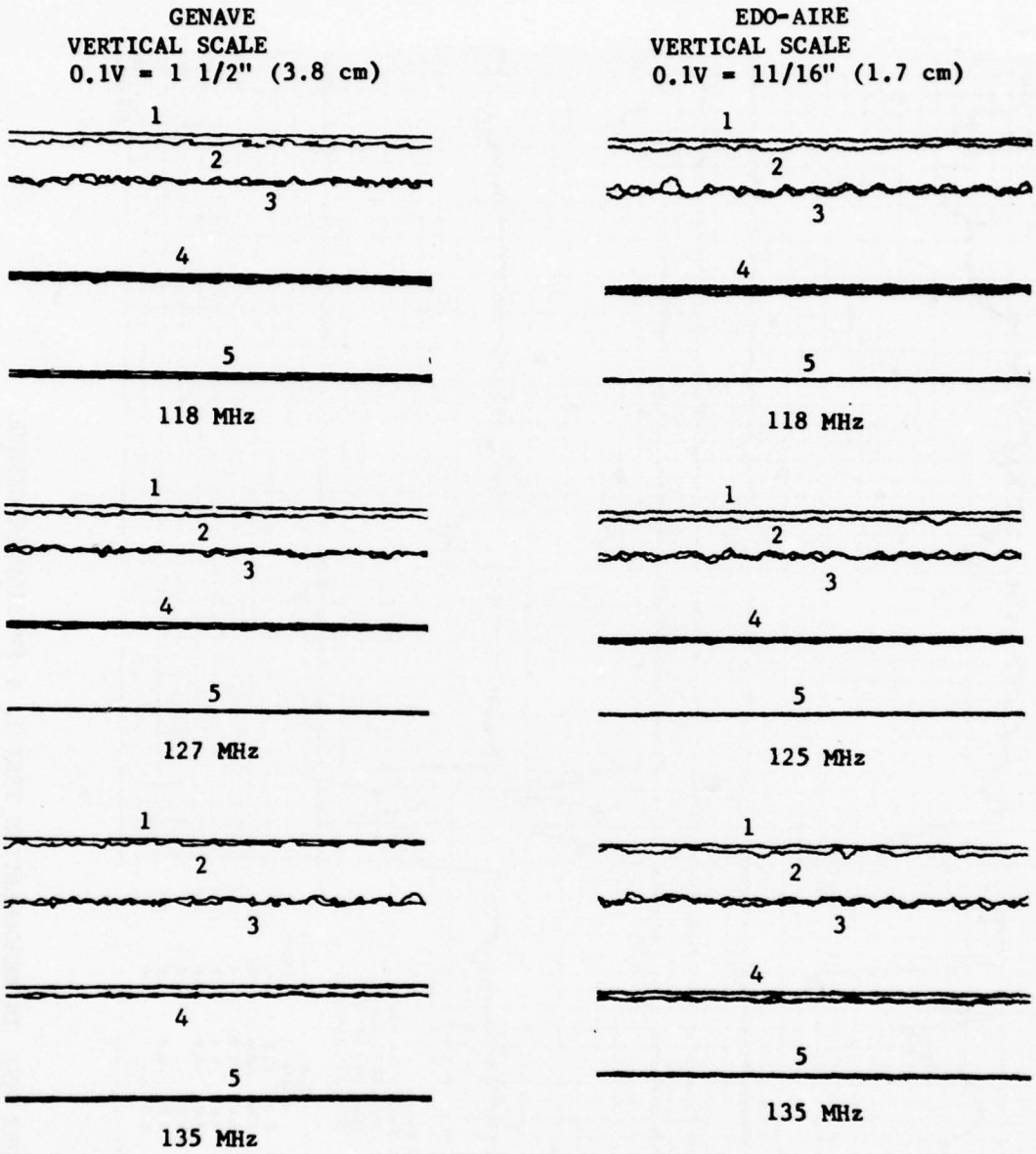


FIGURE 198. INTERMODULATION TEST 4, 2 FM SIGNALS MARK 12



LEGEND

FM SIGNAL dBm (AM SIGNAL dBm)

1. (-85) dBM
2. -20(-85)
3. -10(-85), 0(-85)
4. (-75), -20(-75), -10(-75), 0(-75)
5. (-65), -20(-65), -10(-65), 0(-65)

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FIGURE 199. AGC RESPONSE, AM & FM SIGNALS GENAVE, EDO-AIRE

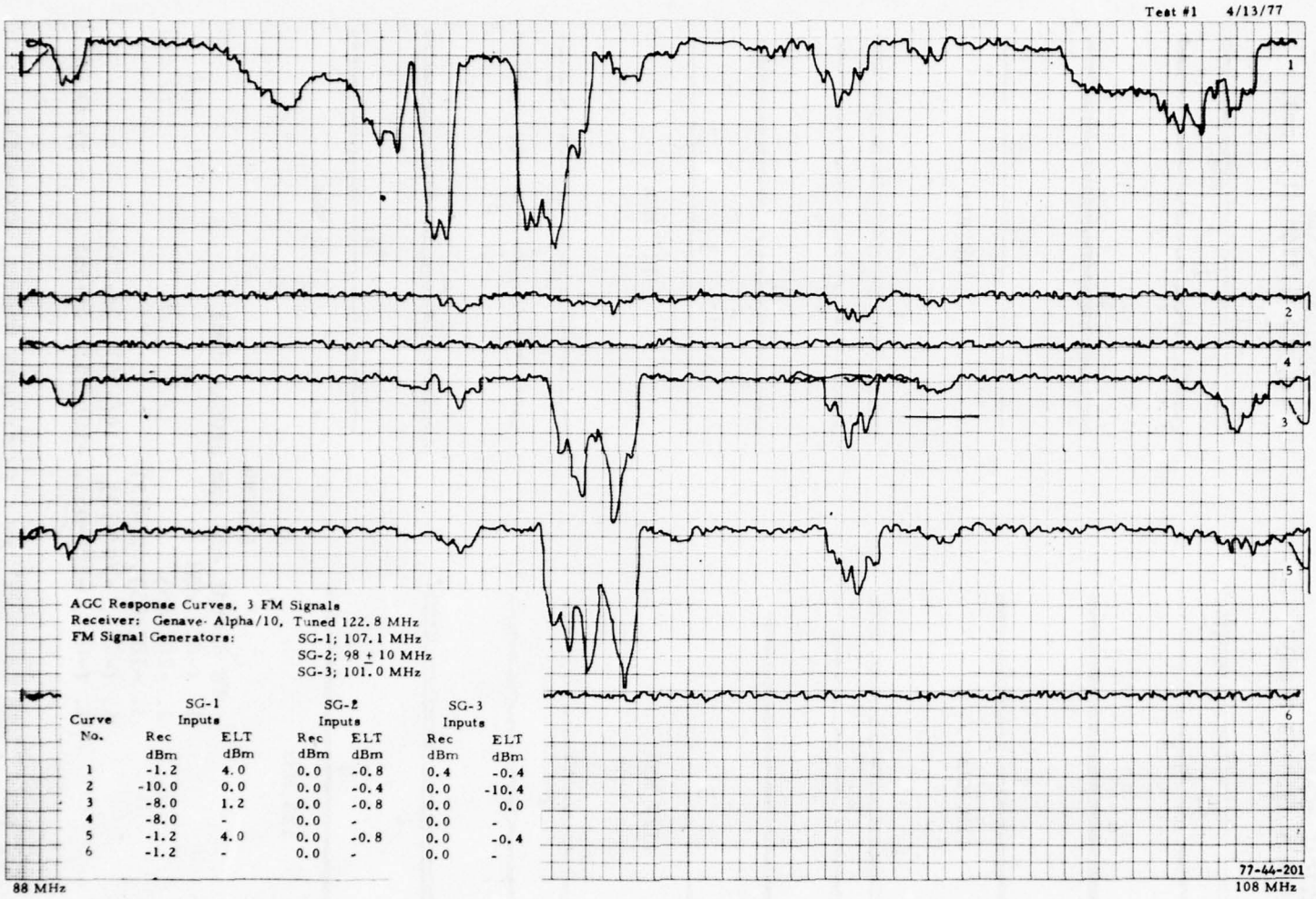


FIGURE 200. INTERMODULATION TEST 1, 3 FM SIGNALS GENAVE

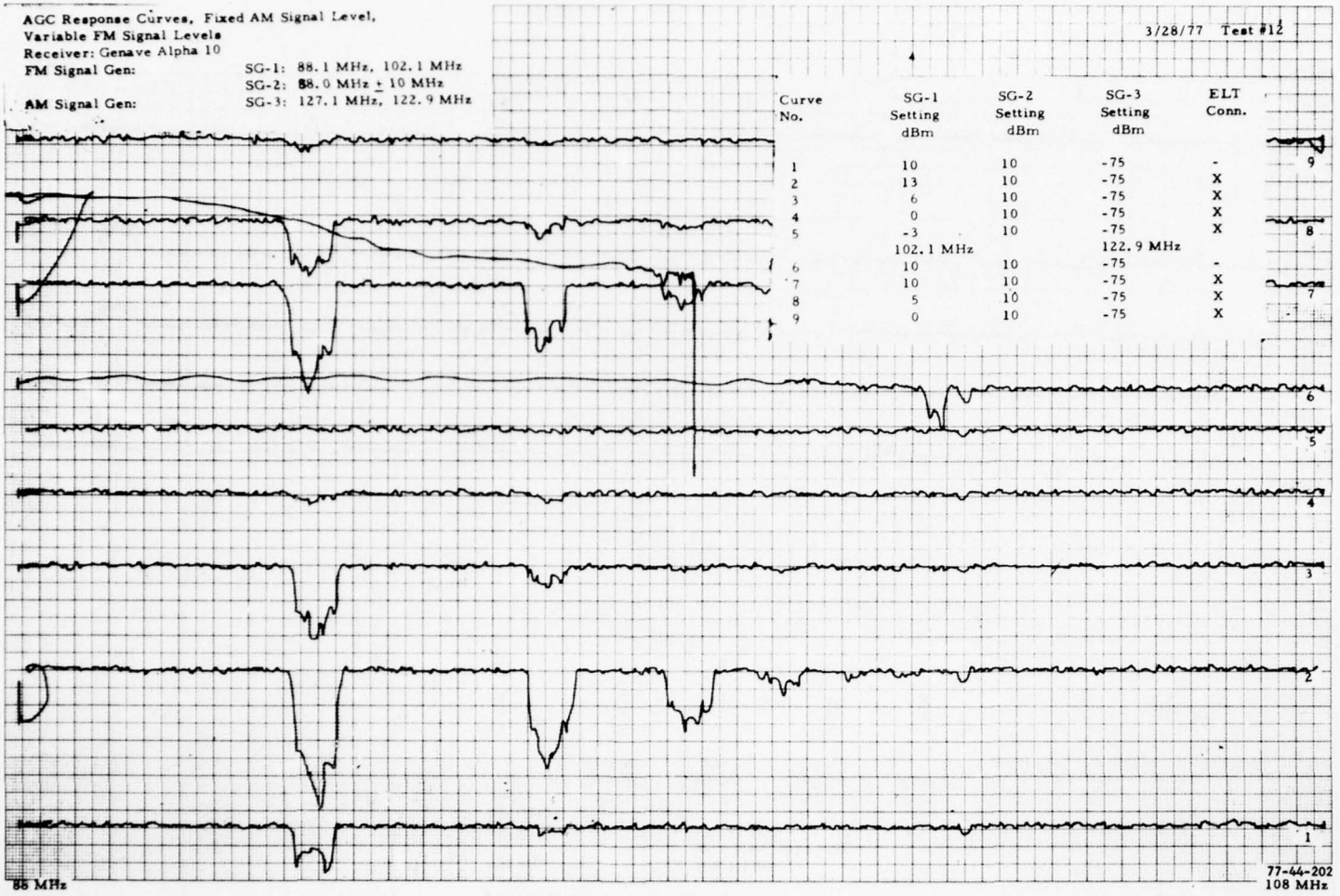


FIGURE 201. INTERMODULATION TEST 12, 2 SIGNALS GENAVE

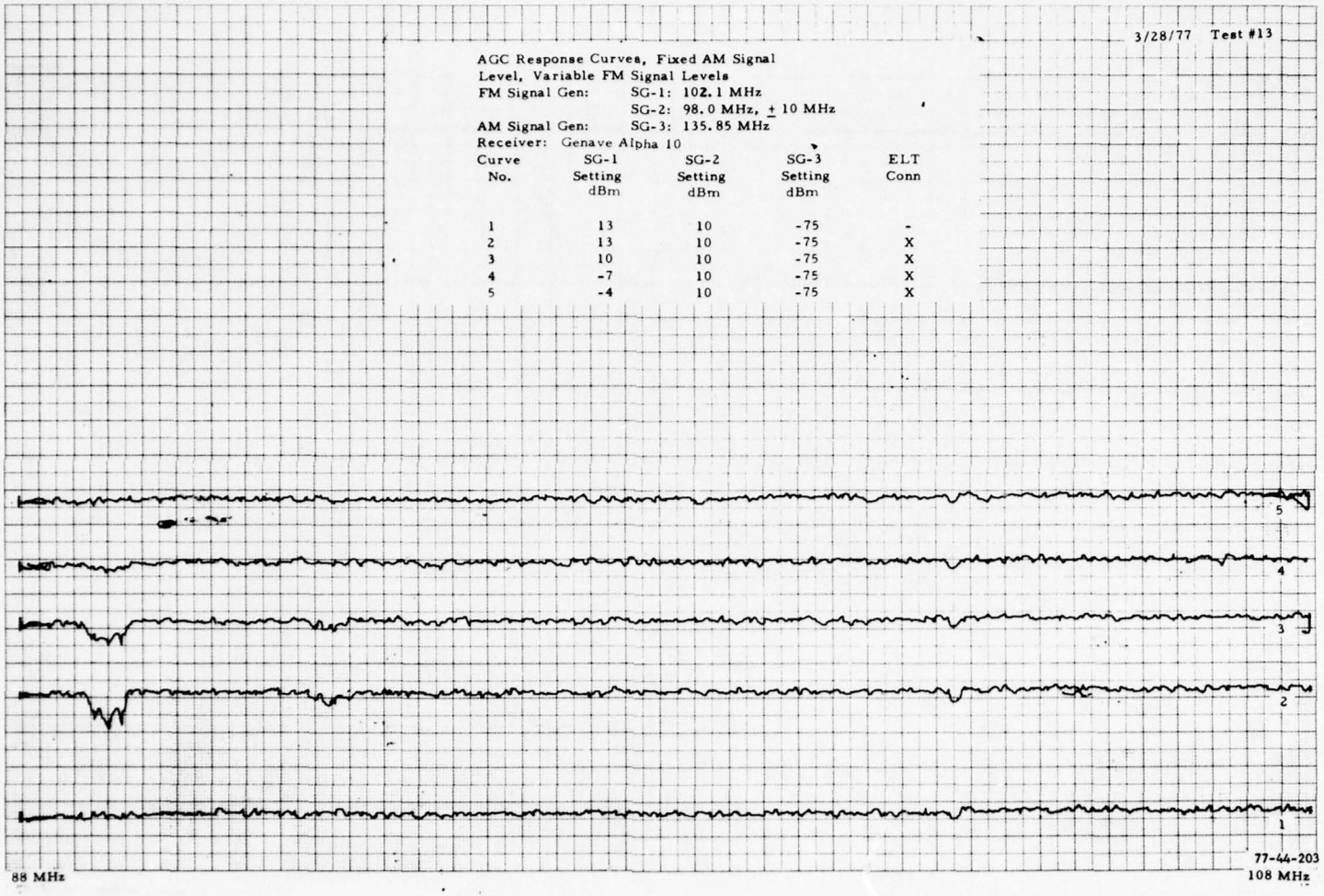
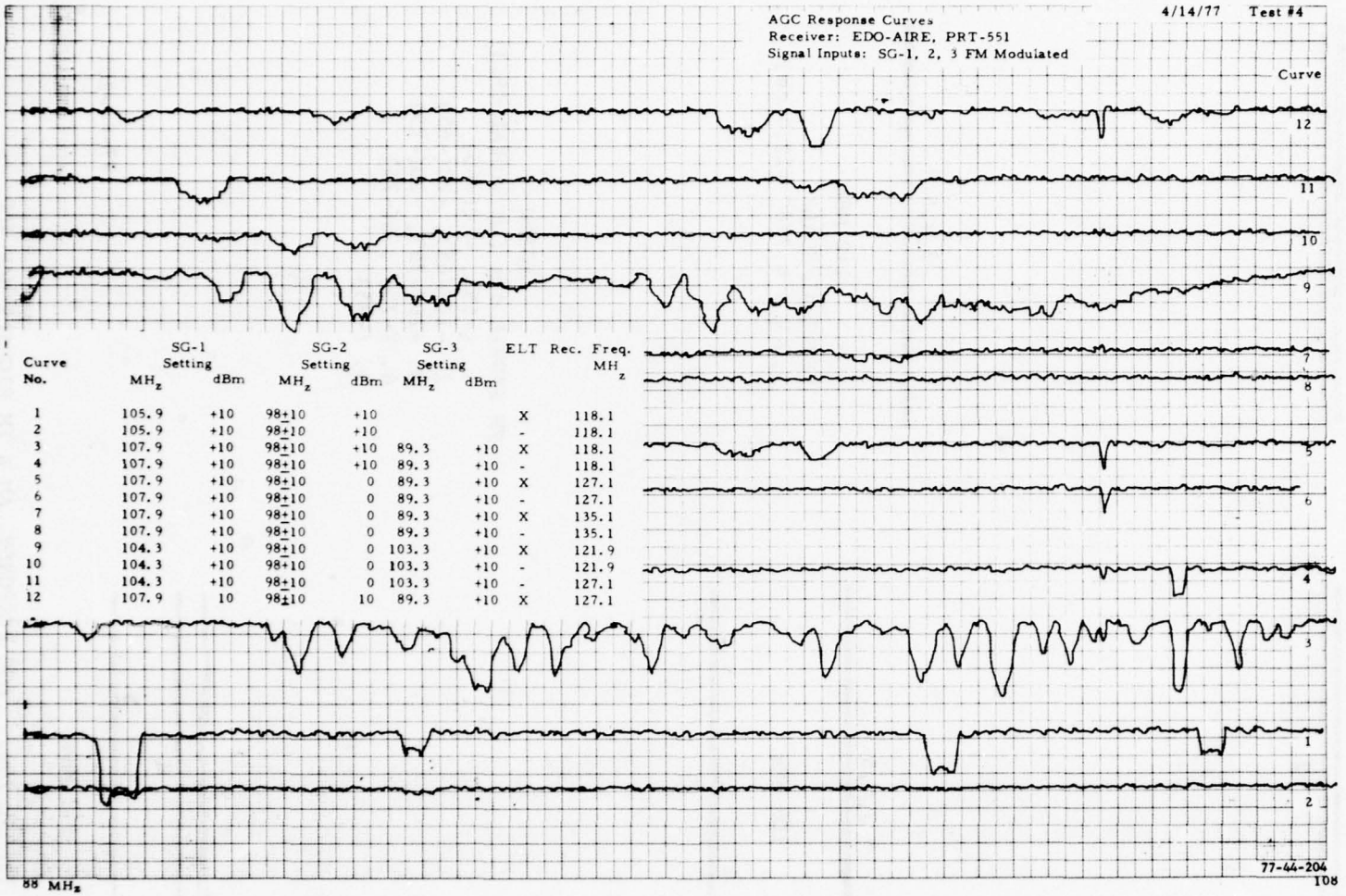
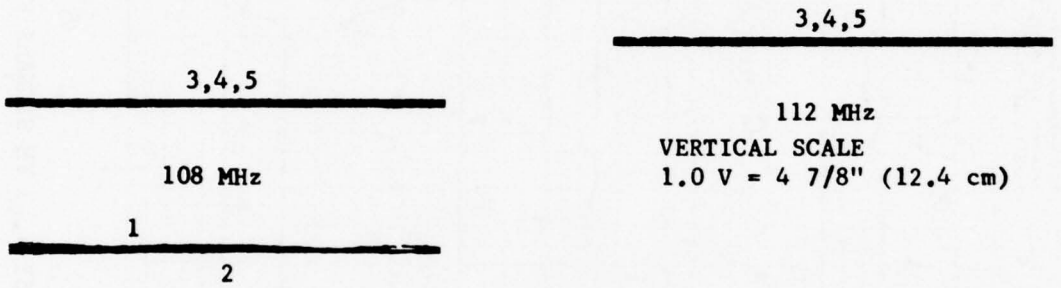


FIGURE 202. INTERMODULATION TEST 13, 2 FM SIGNALS GENAVE



Curve No.	SG-1 Setting MHz	SG-1 dBm	SG-2 Setting MHz	SG-2 dBm	SG-3 Setting MHz	SG-3 dBm	ELT	Rec. Freq. MHz
1	105.9	+10	98±10	+10			X	118.1
2	105.9	+10	98±10	+10			-	118.1
3	107.9	+10	98±10	+10	89.3	+10	X	118.1
4	107.9	+10	98±10	+10	89.3	+10	-	118.1
5	107.9	+10	98±10	0	89.3	+10	X	127.1
6	107.9	+10	98±10	0	89.3	+10	-	127.1
7	107.9	+10	98±10	0	89.3	+10	X	135.1
8	107.9	+10	98±10	0	89.3	+10	-	135.1
9	104.3	+10	98±10	0	103.3	+10	X	121.9
10	104.3	+10	98±10	0	103.3	+10	-	121.9
11	104.3	+10	98±10	0	103.3	+10	-	127.1
12	107.9	10	98±10	10	89.3	+10	X	127.1

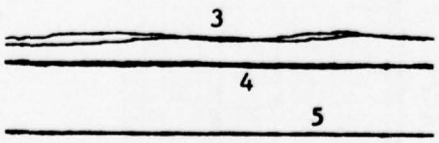
FIGURE 203. INTERMODULATION TEST 4, 3 FM SIGNALS EDO-AIRE



LEGEND

FM SIGNAL dBm (AM SIGNAL dBm)

1. (-65), -20(-65)
2. -10(-65), -20(-65)
3. -20(-75), -10(-75)
4. (-75) , 0(-75)
5. (-85)



117 MHz

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FIGURE 204. AGC RESPONSE, AM & FM SIGNALS NAV 400

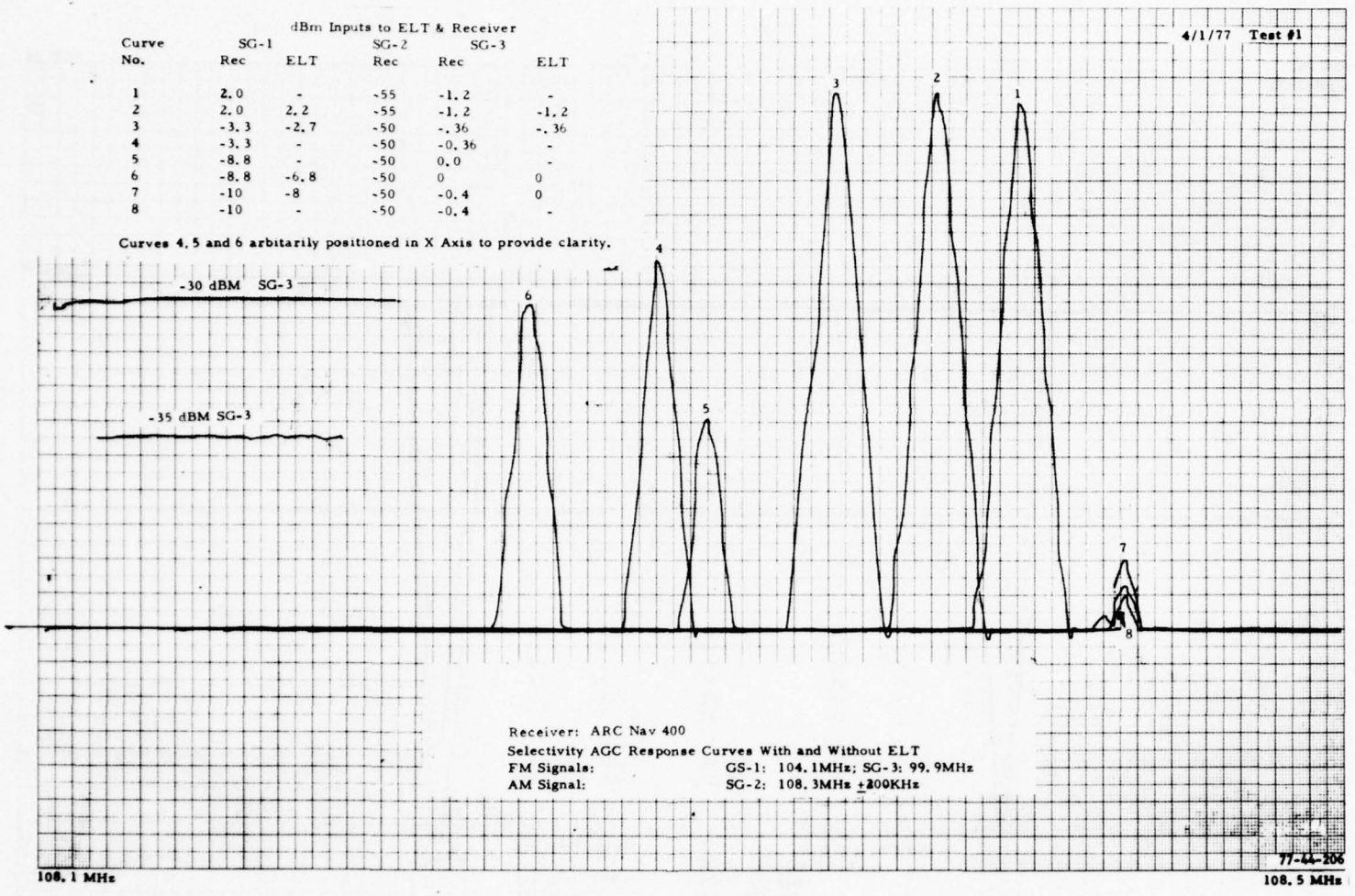


FIGURE 205. INTERMODULATION TEST 1, 2 FM SIGNALS NAV 400

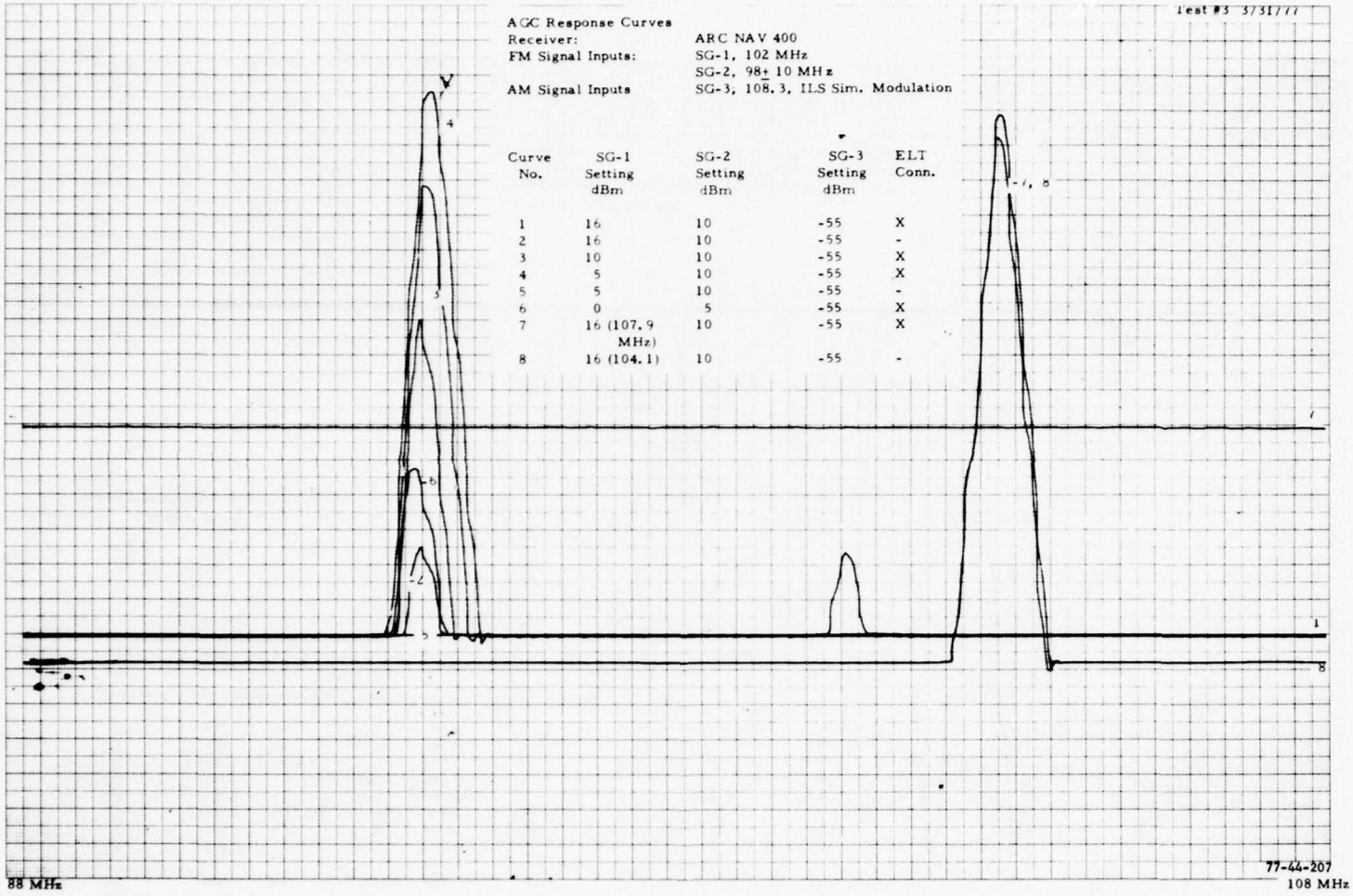


FIGURE 206. INTERMODULATION TEST 3, 2 FM SIGNALS NAV 400

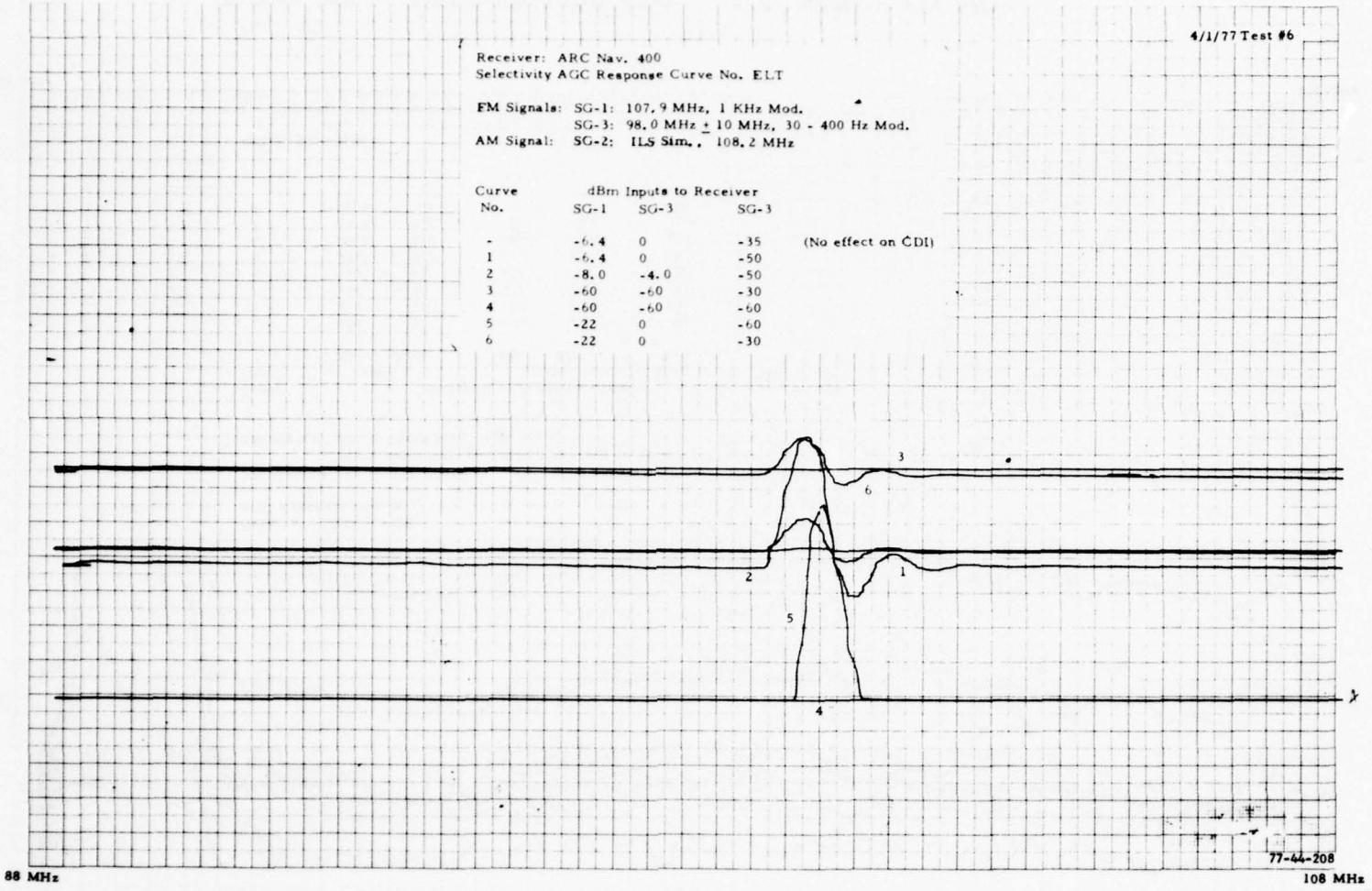


FIGURE 207. INTERMODULATION TEST 6, 2 FM SIGNALS NAV 400

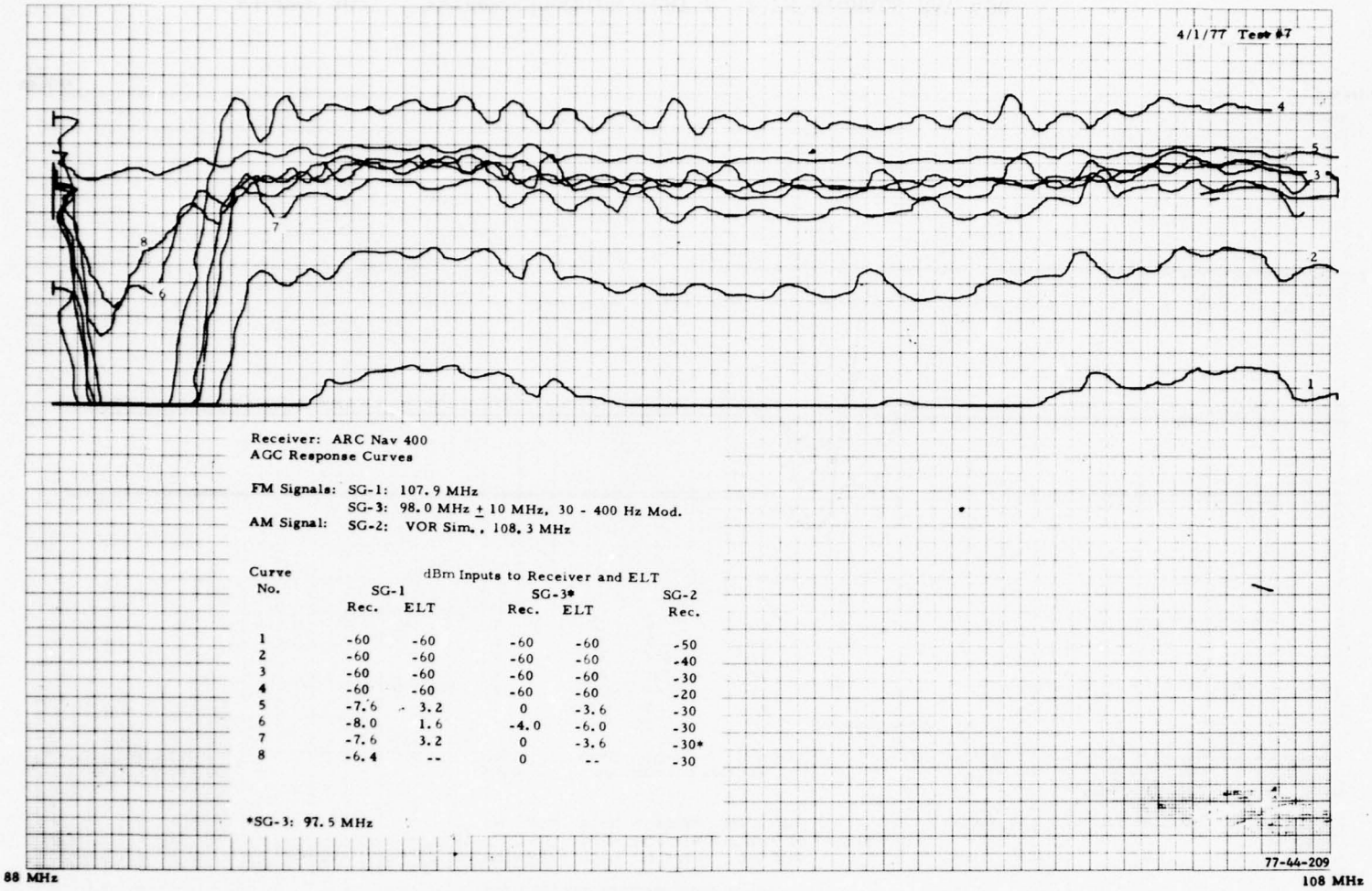
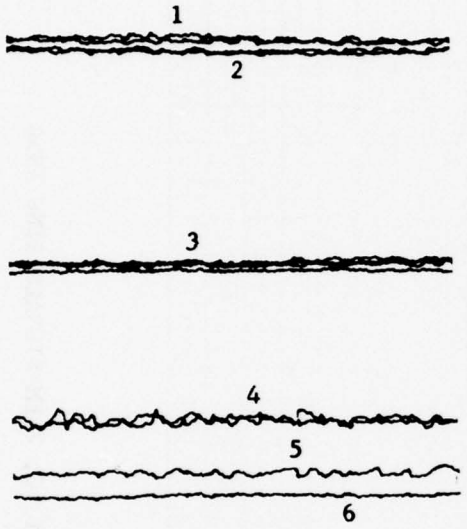
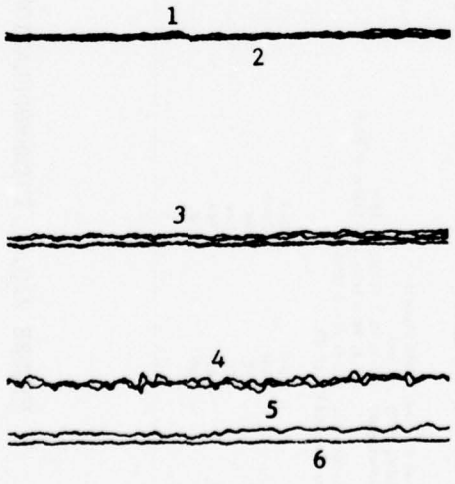


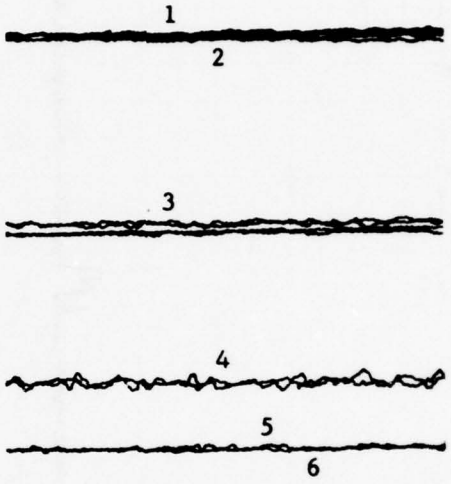
FIGURE 208. INTERMODULATION TEST 7, 2 FM SIGNALS NAV 400



118 MHz



135 MHz



127 MHz

VERTICAL SCALE

0.IV = $\frac{9}{16}$" (1.4 cm)

LEGEND

FM SIGNAL dBm (AM SIGNAL dBm)

1. (-65), -20(-65)
2. -10(65), 0(-65)
3. (-75) , -20(-75), -10(-75), 0(-75)
4. -10(-85), 0(-85)
5. -20(-85)
6. (-85)

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FIGURE 209. AGC RESPONSE, AM & FM SIGNALS KING 195B

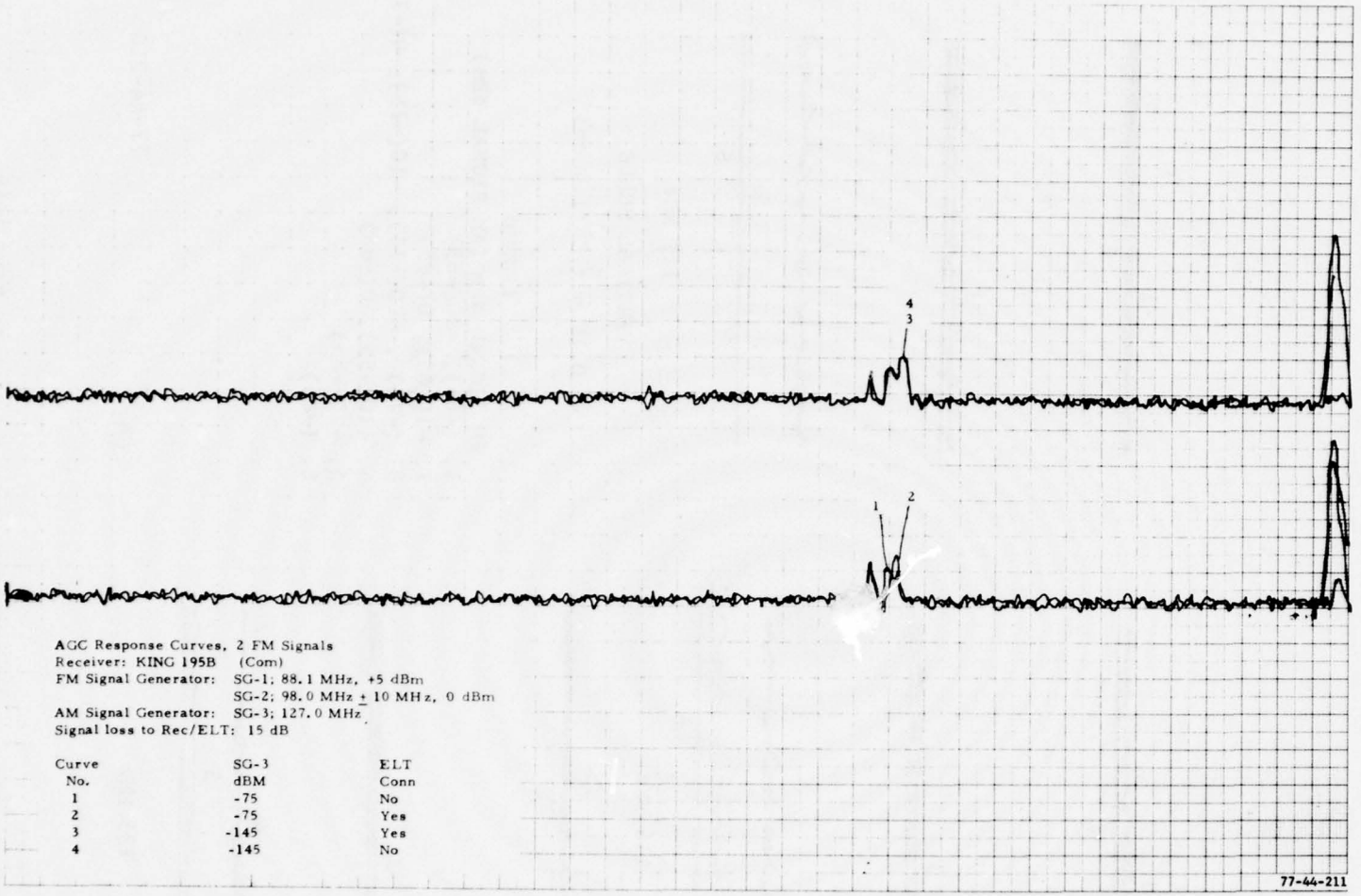


FIGURE 210. INTERMODULATION TEST 1C, 2 FM SIGNALS KING 195B

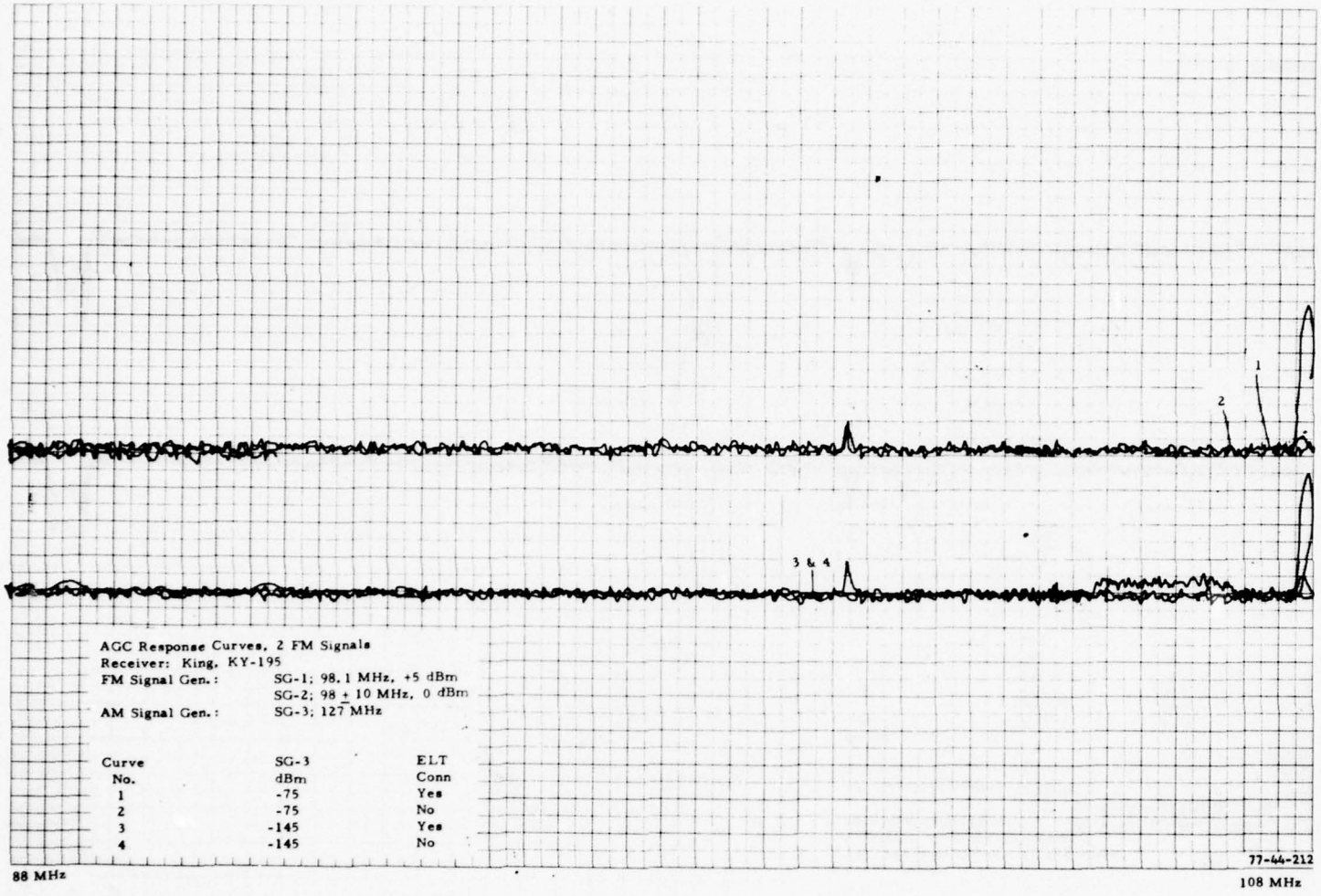


FIGURE 211. INTERMODULATION TEST 1D, 2 FM SIGNALS KING 195B

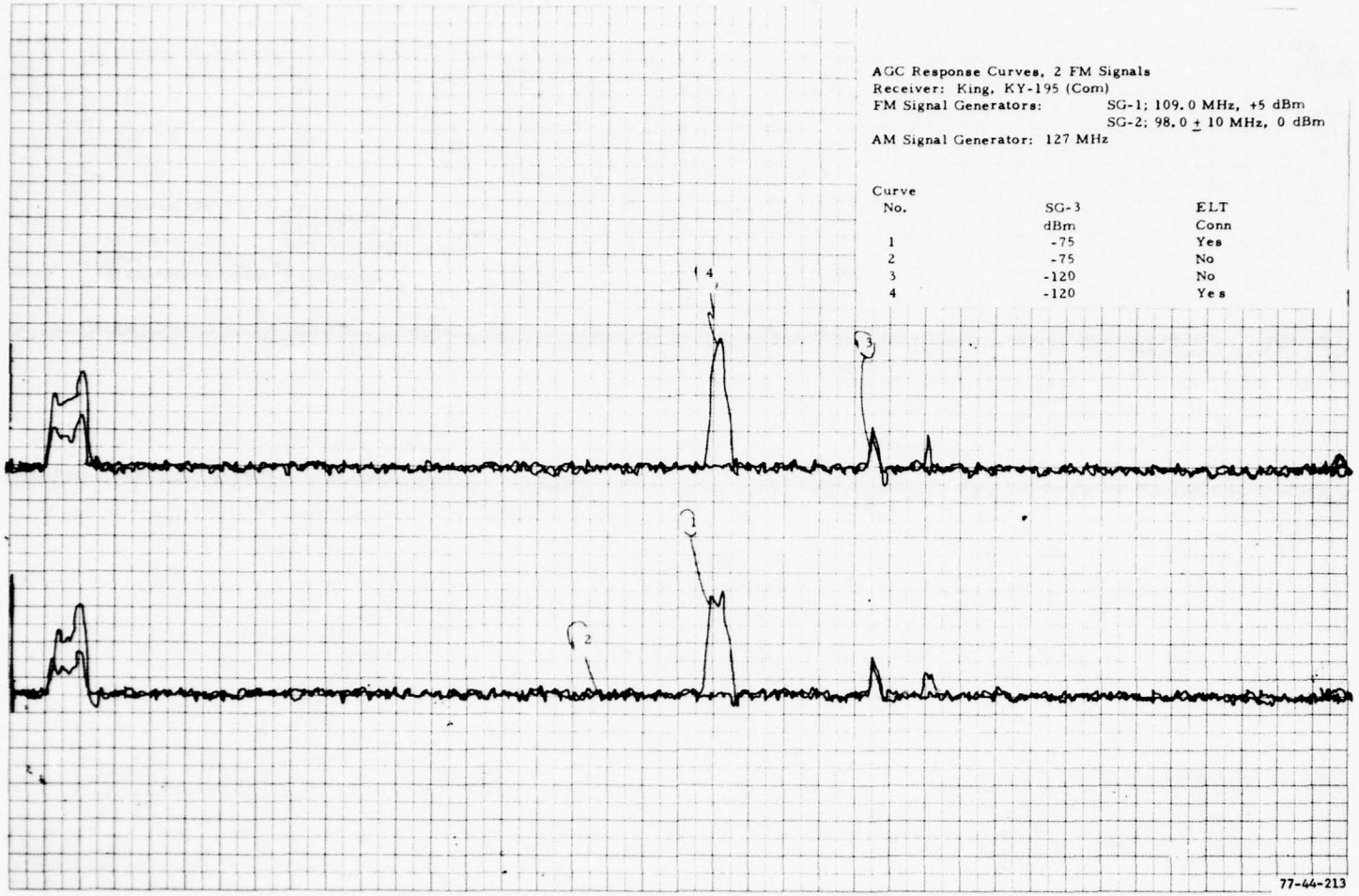


FIGURE 212. INTERMODULATION TEST 3C, 2 FM SIGNALS KING 195B

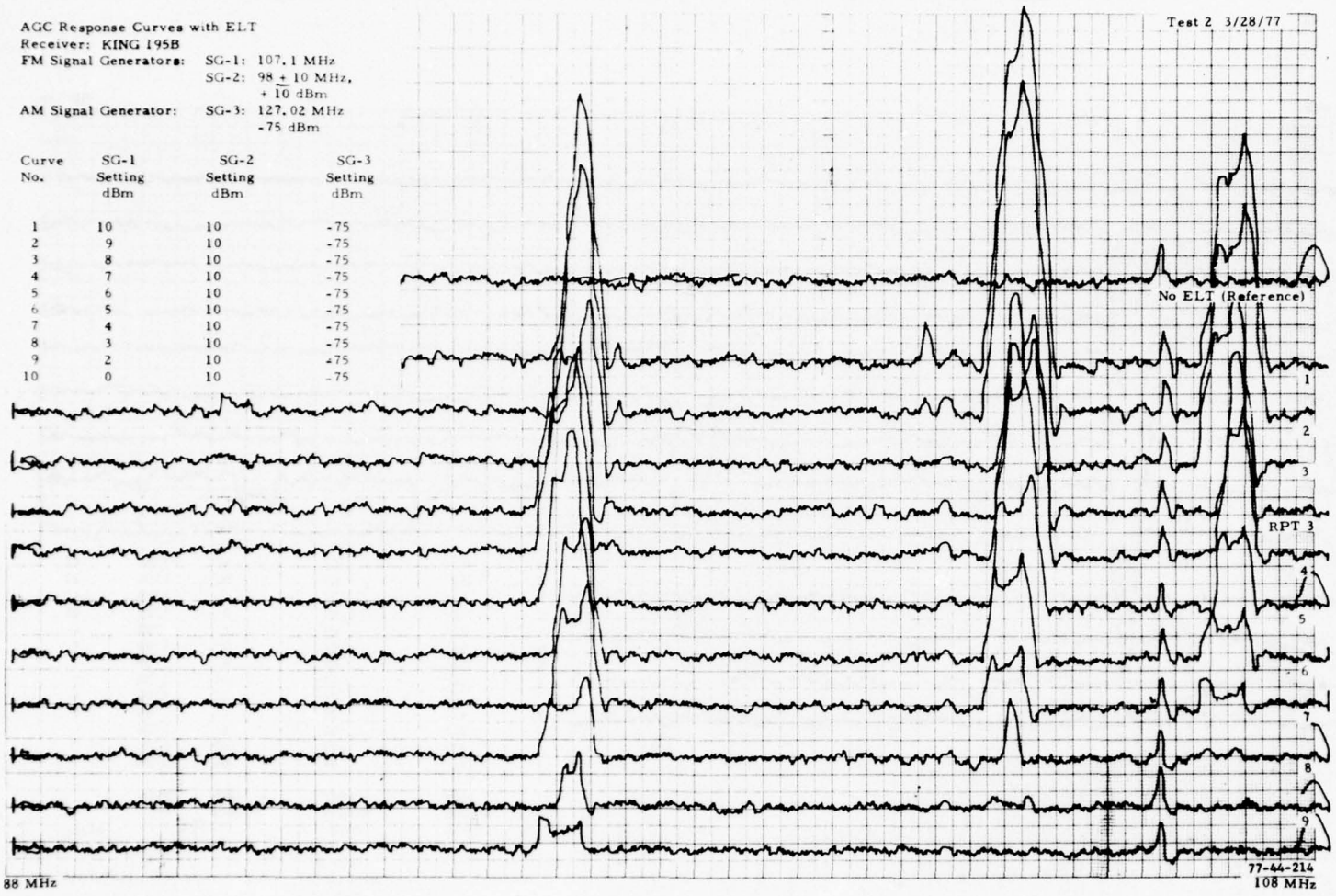


FIGURE 213. INTERMODULATION TEST 2, 2 FM SIGNALS KING 195B

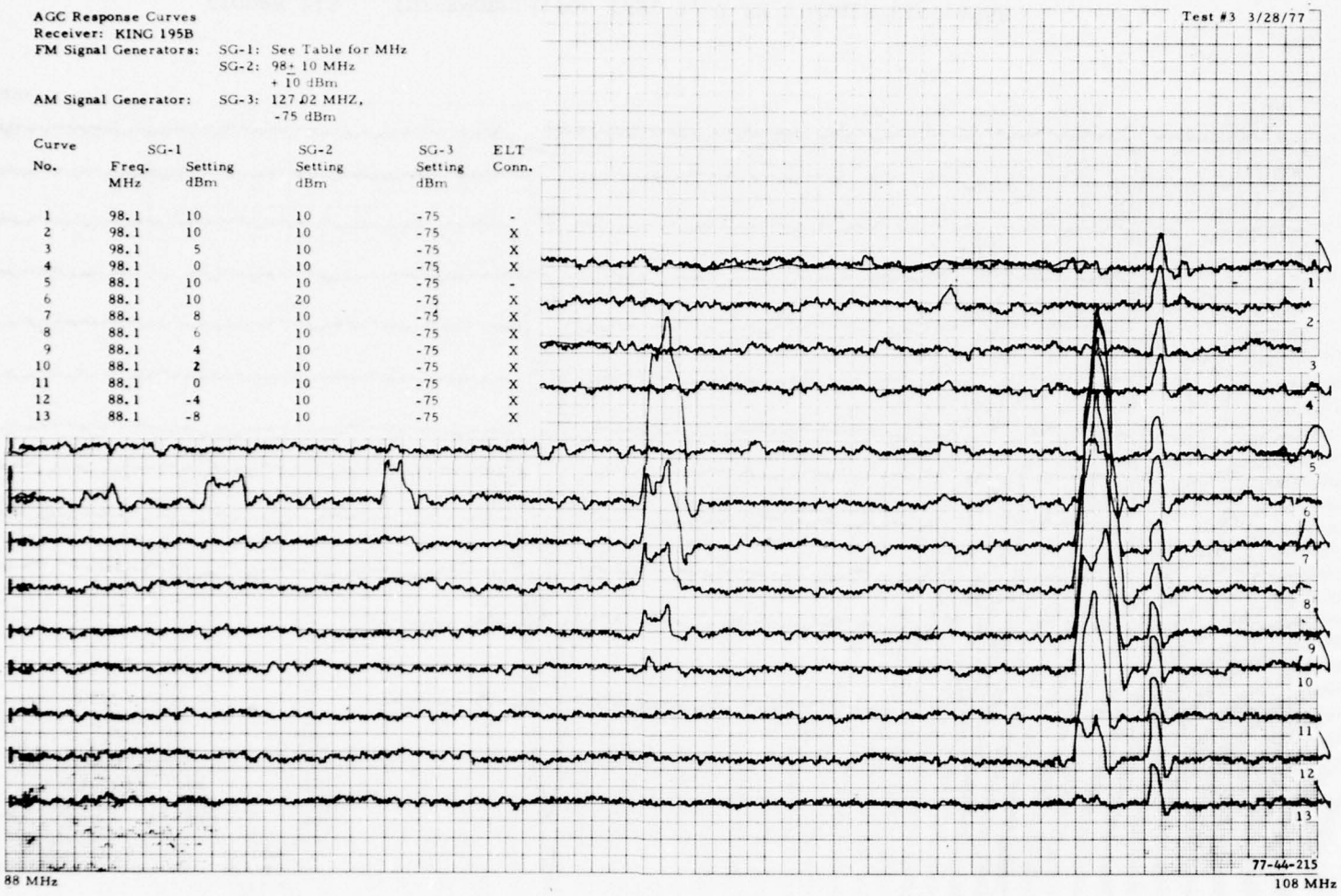


FIGURE 214. INTERMODULATION TEST 3, 2 FM SIGNALS KING 195B

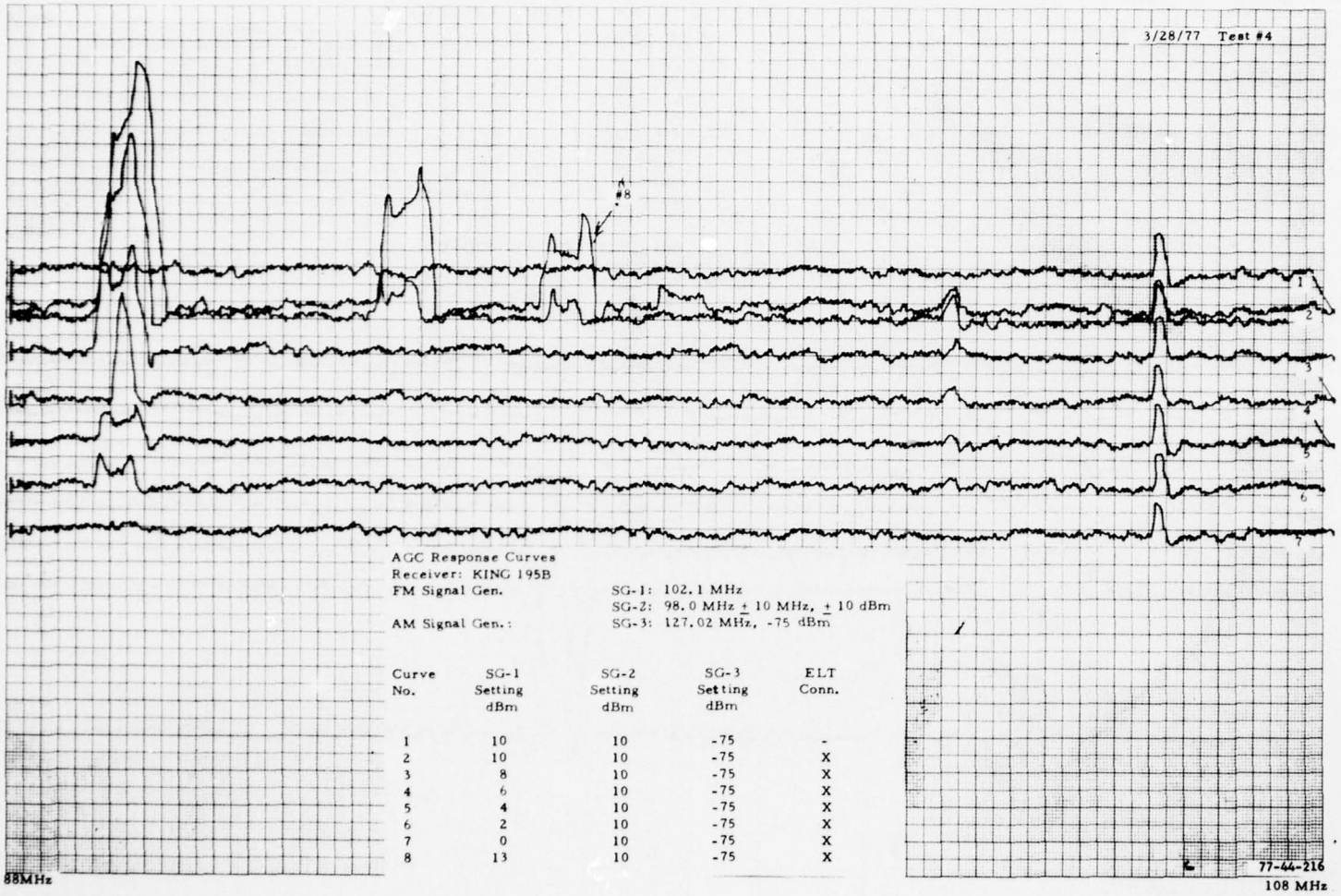


FIGURE 215. INTERMODULATION TEST 4, 2 FM SIGNALS KING 195B

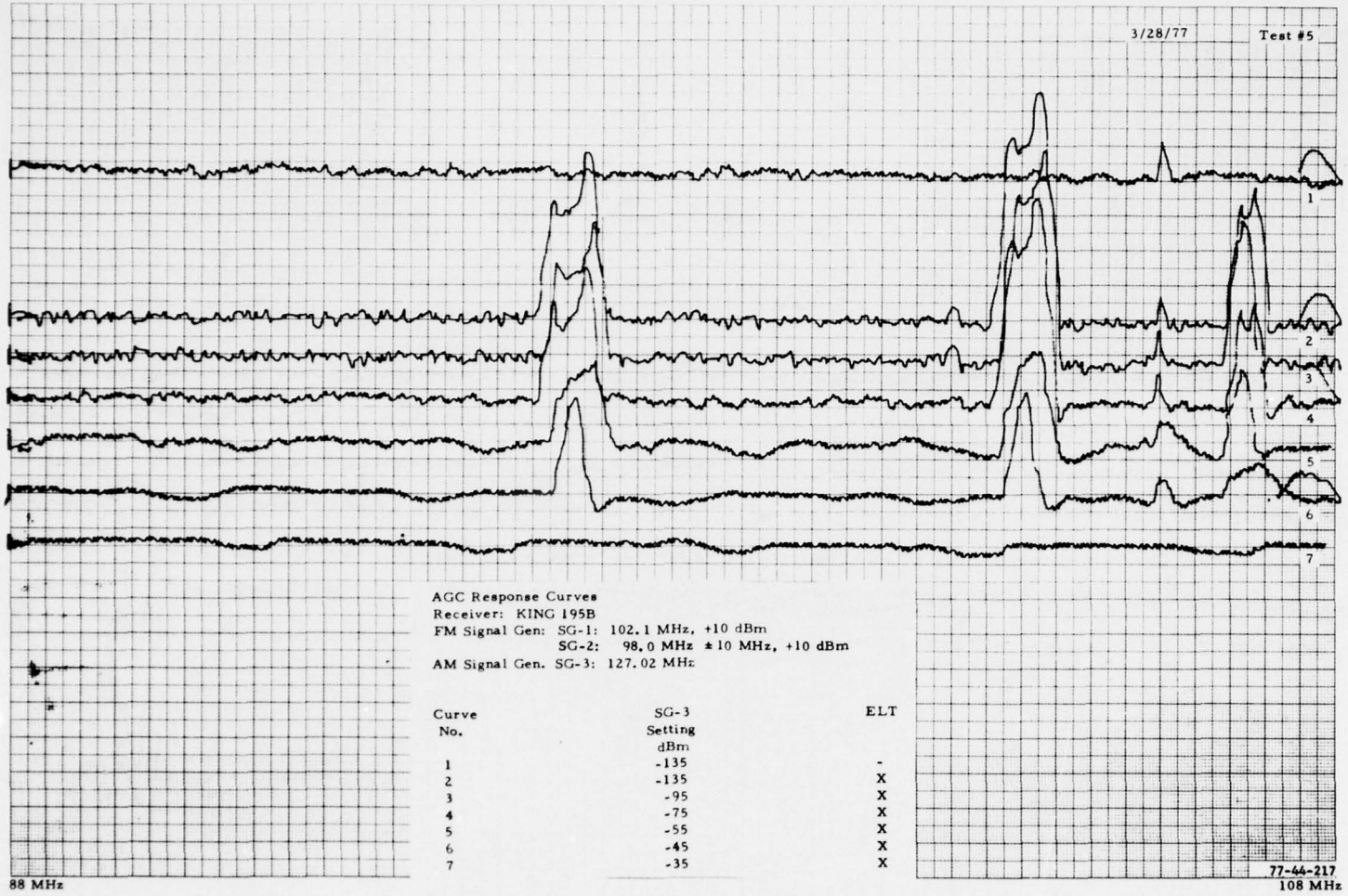


FIGURE 216. INTERMODULATION TEST 5, 2 FM SIGNALS KING 195B

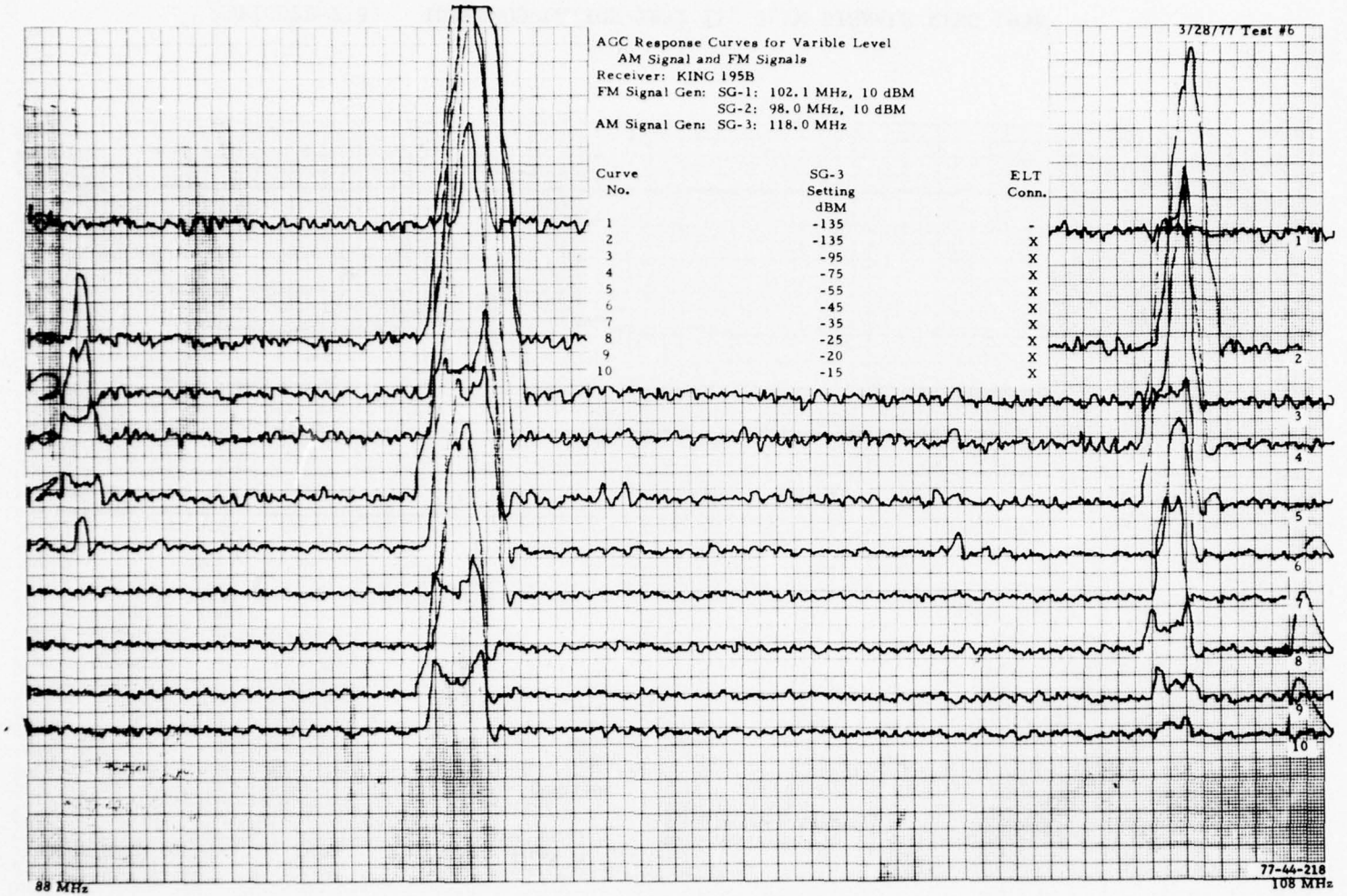


FIGURE 217. INTERMODULATION TEST 6, 2 FM SIGNALS KING 195B

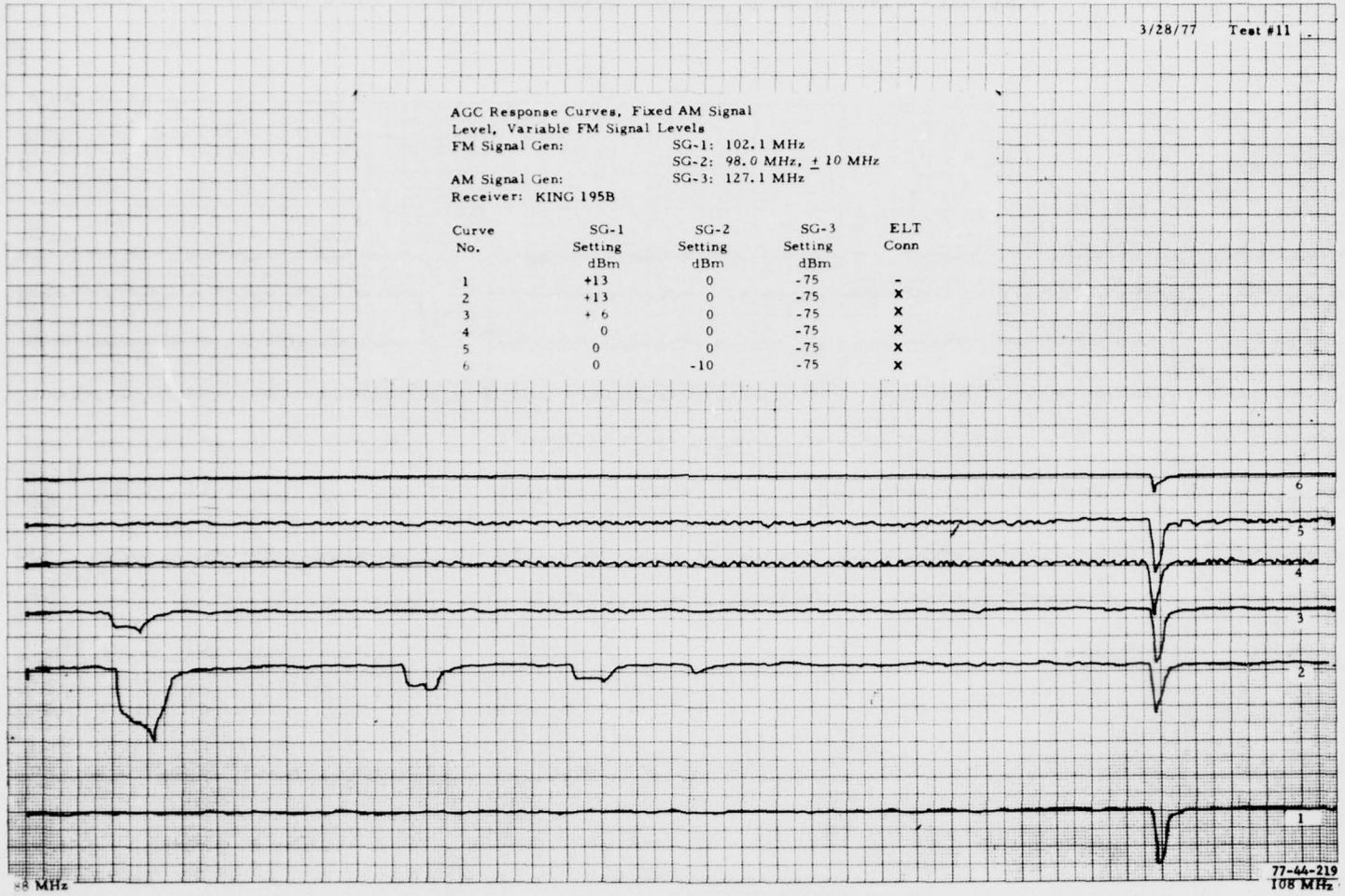
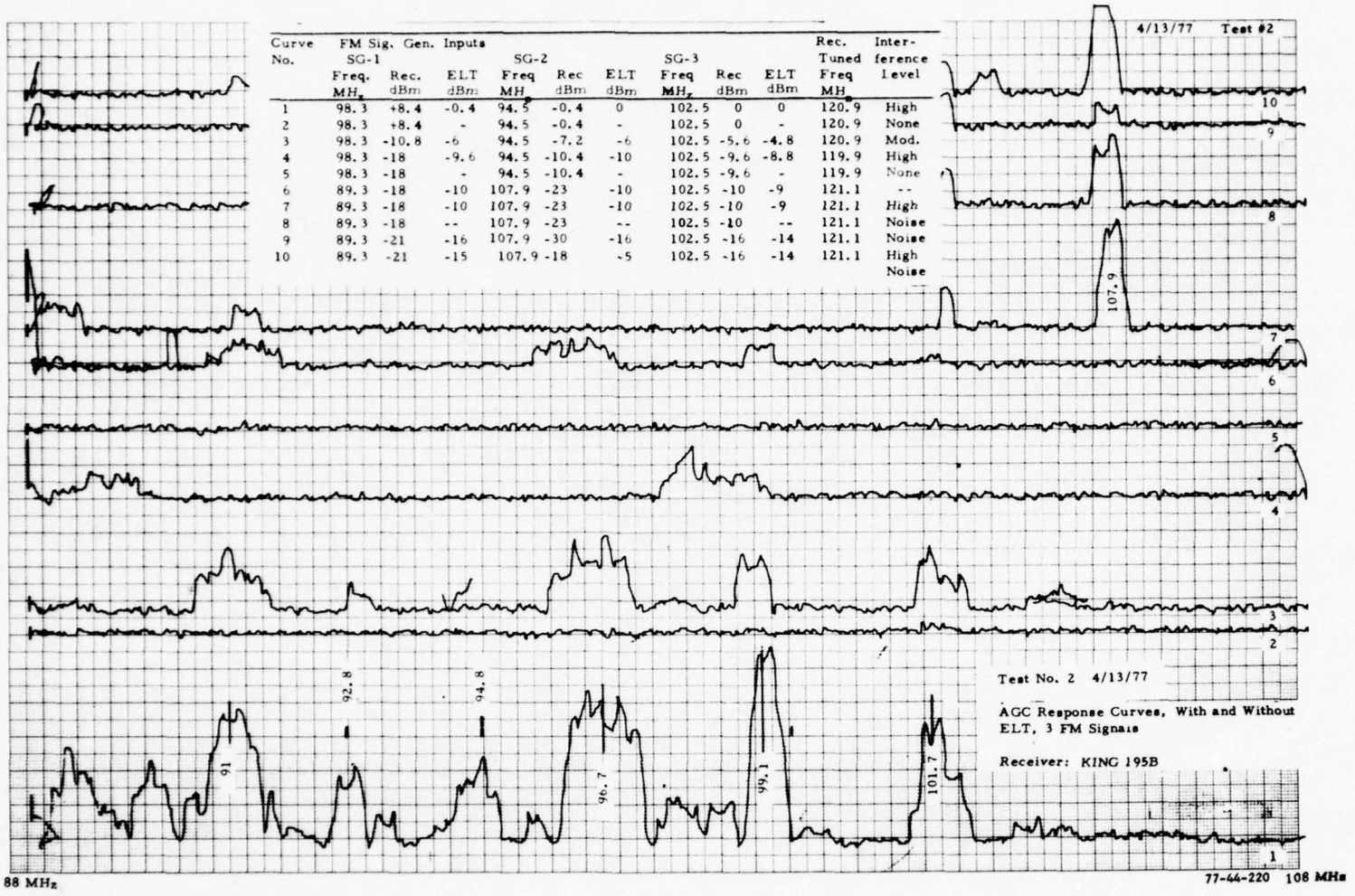


FIGURE 218. INTERMODULATION TEST 11, 2 FM SIGNALS KING 195B



Curve No.	FM Sig. Gen. Inputs SG-1 Freq. MHz	SG-1 Rec. dBm	SG-1 ELT dBm	SG-2 Freq MHz	SG-2 Rec dBm	SG-2 ELT dBm	SG-3 Freq MHz	SG-3 Rec dBm	SG-3 ELT dBm	Rec. Tuned Freq MHz	Interference Level
1	98.3	+8.4	-0.4	94.5	-0.4	0	102.5	0	0	120.9	High
2	98.3	+8.4	-	94.5	-0.4	-	102.5	0	-	120.9	None
3	98.3	-10.8	-6	94.5	-7.2	-6	102.5	-5.6	-4.8	120.9	Mod.
4	98.3	-18	-9.6	94.5	-10.4	-10	102.5	-9.6	-8.8	119.9	High
5	98.3	-18	-	94.5	-10.4	-	102.5	-9.6	-	119.9	None
6	89.3	-18	-10	107.9	-23	-10	102.5	-10	-9	121.1	--
7	89.3	-18	-10	107.9	-23	-10	102.5	-10	-9	121.1	High
8	89.3	-18	--	107.9	-23	--	102.5	-10	--	121.1	Noise
9	89.3	-21	-16	107.9	-30	-16	102.5	-16	-14	121.1	Noise
10	89.3	-21	-15	107.9	-18	-5	102.5	-16	-14	121.1	High Noise

FIGURE 219. INTERMODULATION TEST 2, 3 FM SIGNALS KING 195B

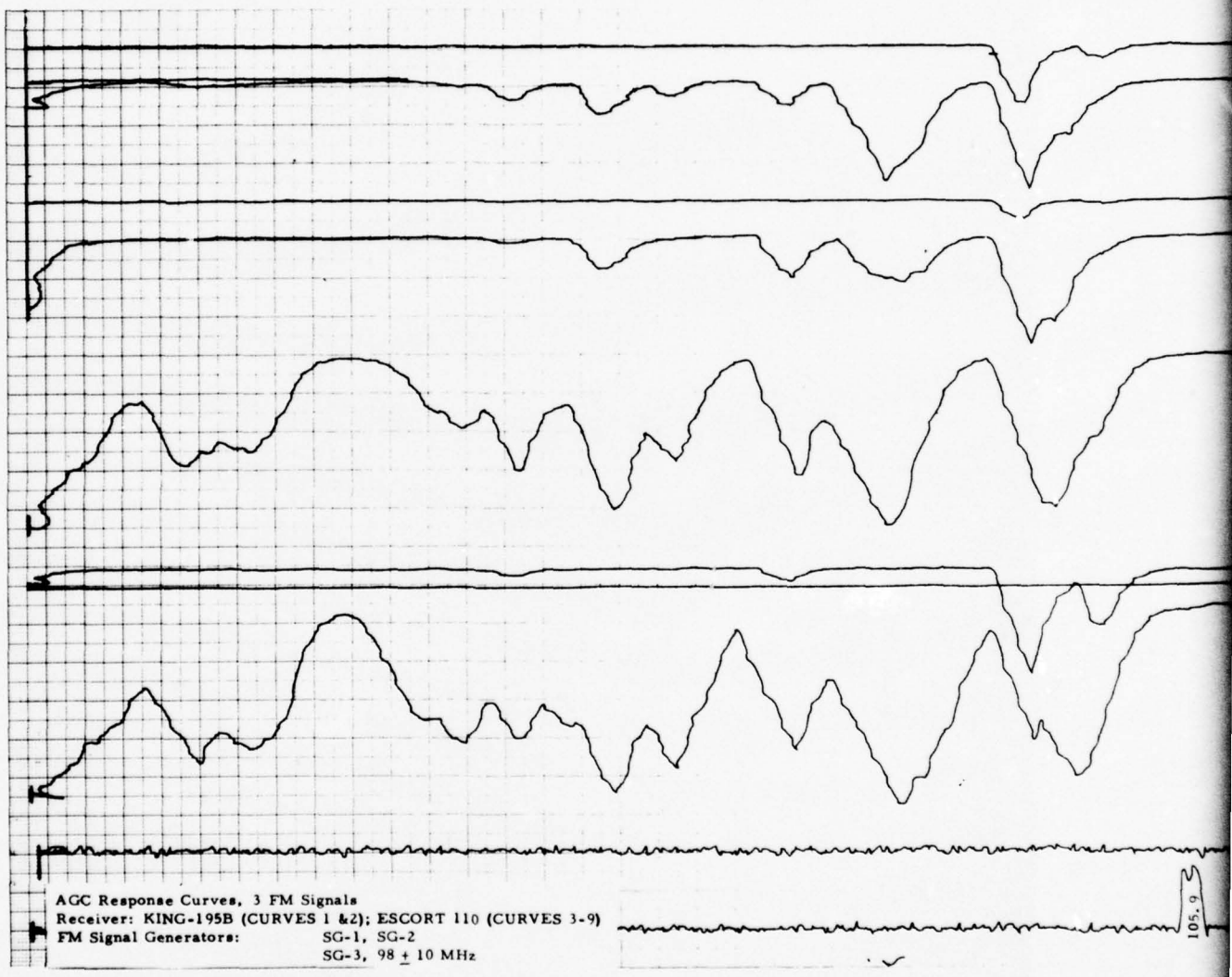
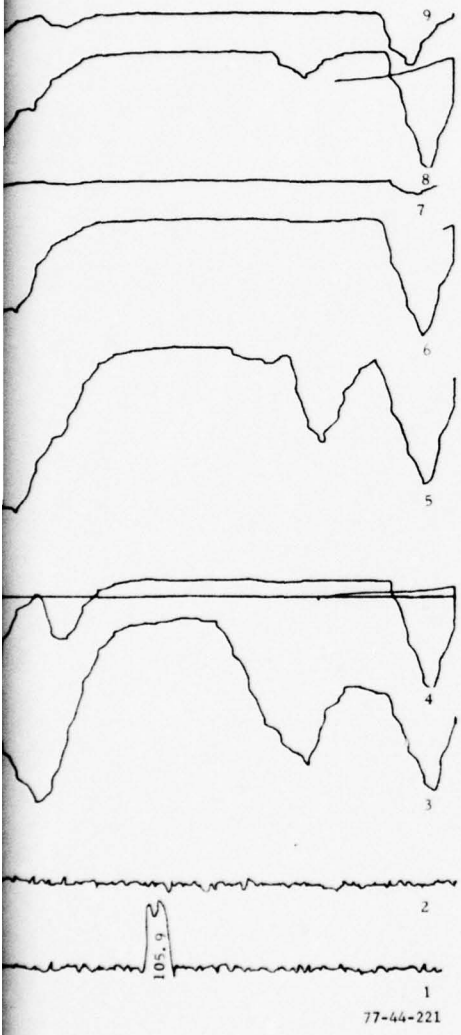


FIGURE 220. INTERMODULATION TE

Test #3 4/13/77



AGC Response Curves, 3 FM Signals
Receiver: King KY-195 (Curves 1 & 2); 121.3 MHz
Escort 110 (Curves 3-9) 109.9 MHz
FM Signal Generators: SG-1, SG-2,
SG-3: 98 ± 10 MHz;
Curves 3 to 9 data taken at
89.3 MHz

Curve No.	SG-1 Inputs Freq. MHz	Rec. dBm	ELT dBm	SG-2 Inputs Freq. MHz	Rec. dBm	ELT. dBm	SG-3 Freq. MHz	Rec. dBm	ELT dBm	REMARKS
1	90.5	-14	-10	105.9	-10	-5	98	5	5	Severe Audio Int.
2	90.5	-14	-	105.9	-10	-	98	5	-	Aud. Int. Less Sev
-	90.5	-14.4	-10.0	105.9	-16	-10	98	0	0	W/W.O. ELT *Strong Int.*
-	90.5	-25	-	105.9	-26	-	98	-10	-	High B.G. Noise to this level
3	94.9	0	0	104.3	-3	0	89.3	-8	0	"To" up, SLT CDI Deflection
4	94.9	0	-	104.3	-3	-	89.3	-8	0	
5	94.9	-5	-6	104.3	-6	-8	89.3	-9.5	-10.8	"To" up, SLT CDI Deflection
6	94.9	-9	-10	104.3	-10	-13	89.3	-9	-17	"Flag" Up
7	94.9	-15	-16	104.3	-17	-19	89.3	-15	-21	"Flag" Up
8	94.9	-6	-5	104.3	-11	-10	89.3	-18	-9	"To: Up-Sm. Defl
9	94.9	-6	-	104.3	-11	-	89.3	-18	-	

MODULATION TEST 3, 3 FM SIGNALS KING 195B, ESCORT 110

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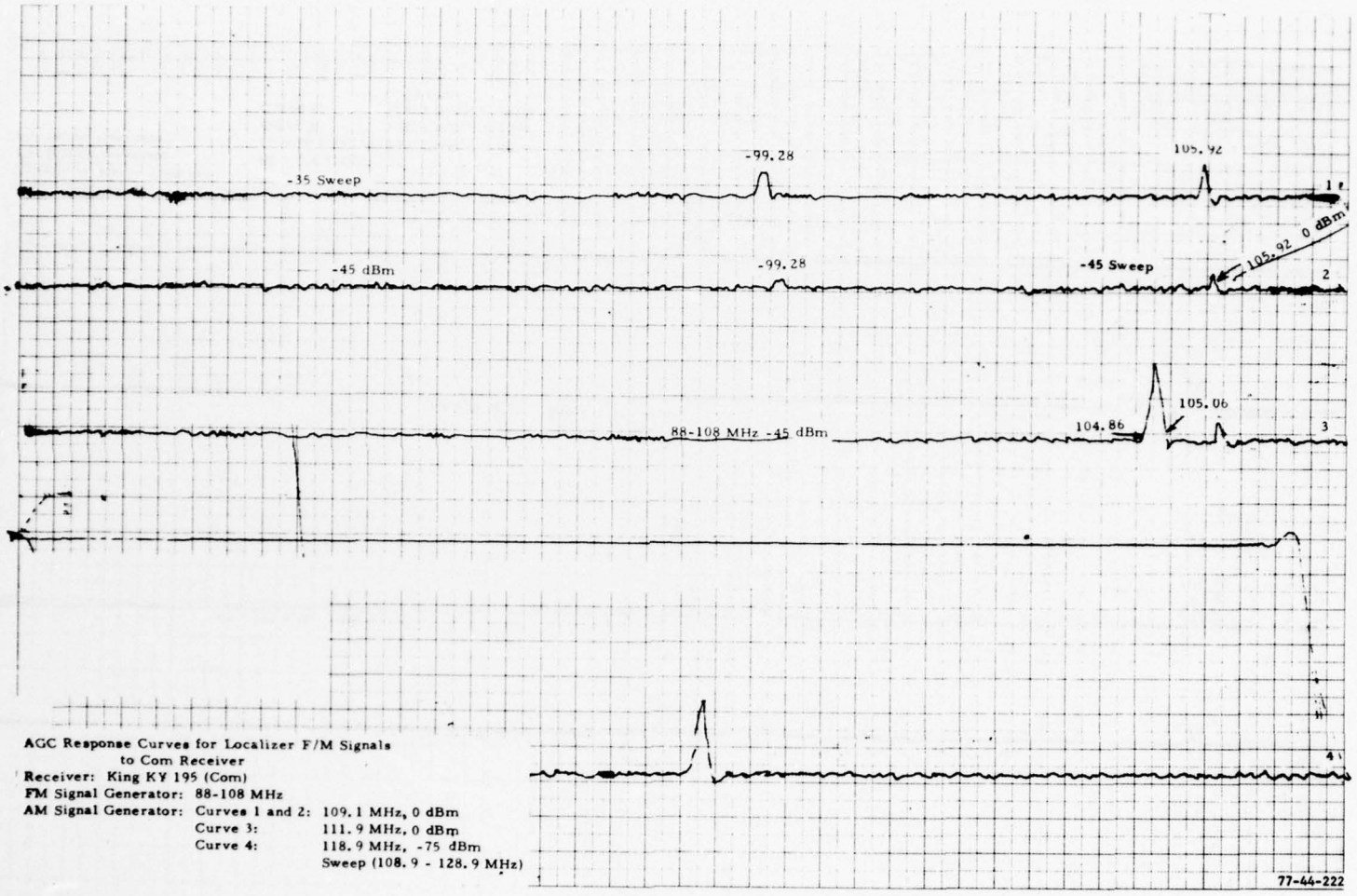


AGC Response Curves for Localizer F/M Signals to Com Receiver
Receiver: King KY 195 (Com)
FM Signal Generator: 88-108 MHz
AM Signal Generator: Curves 1 and 2: 109.1 MHz, 0 dBm
Curve 3: 111.9 MHz, 0 dBm
Curve 4: 118.9 MHz, -75 dBm
Sweep (108.9 - 128.9 MHz)

FIGURE 221. ILS AND FM INTERMODULATION TO COM REC.

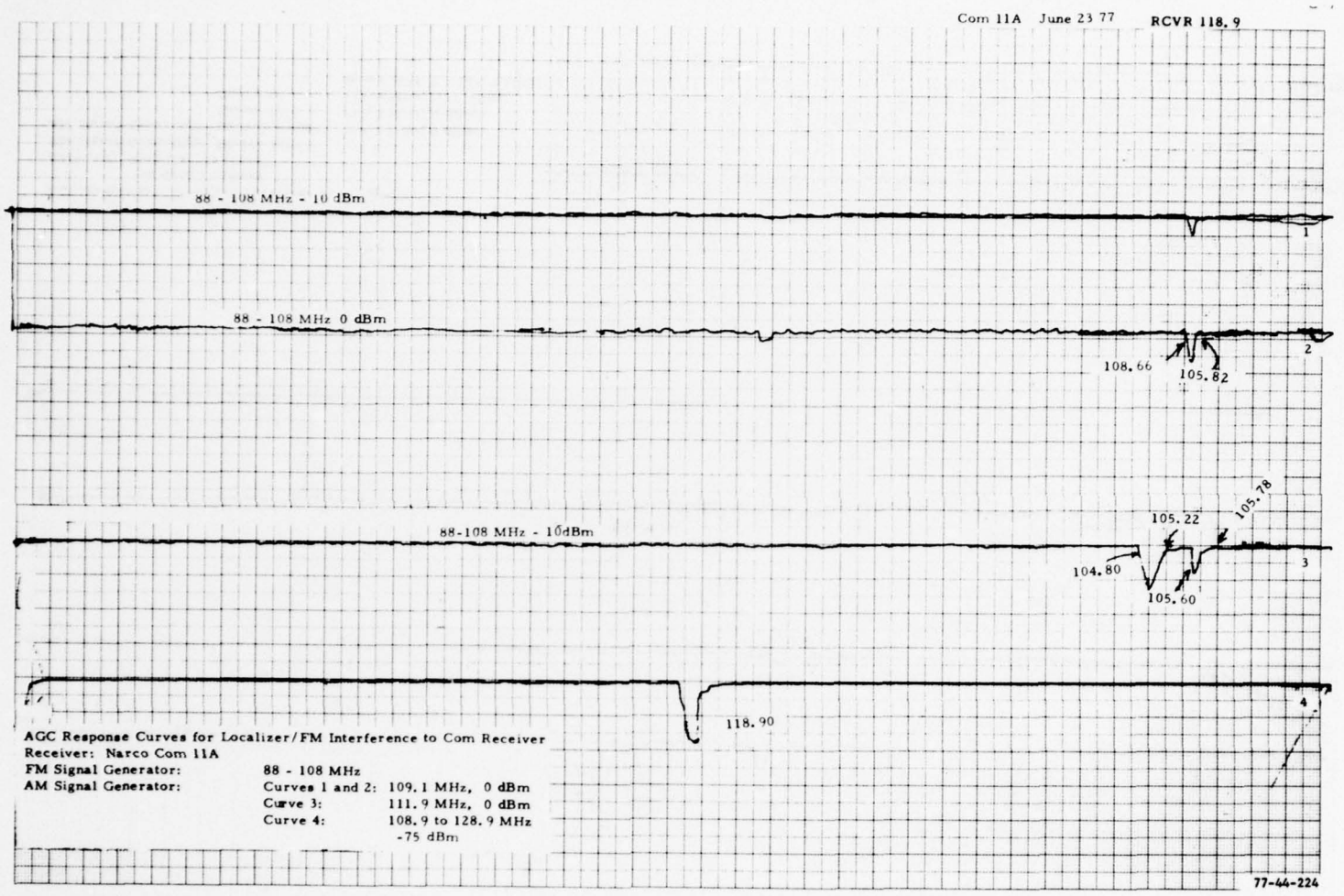


FIGURE 222. AGC RESPONSE, AM & FM SIGNALS COM 11A

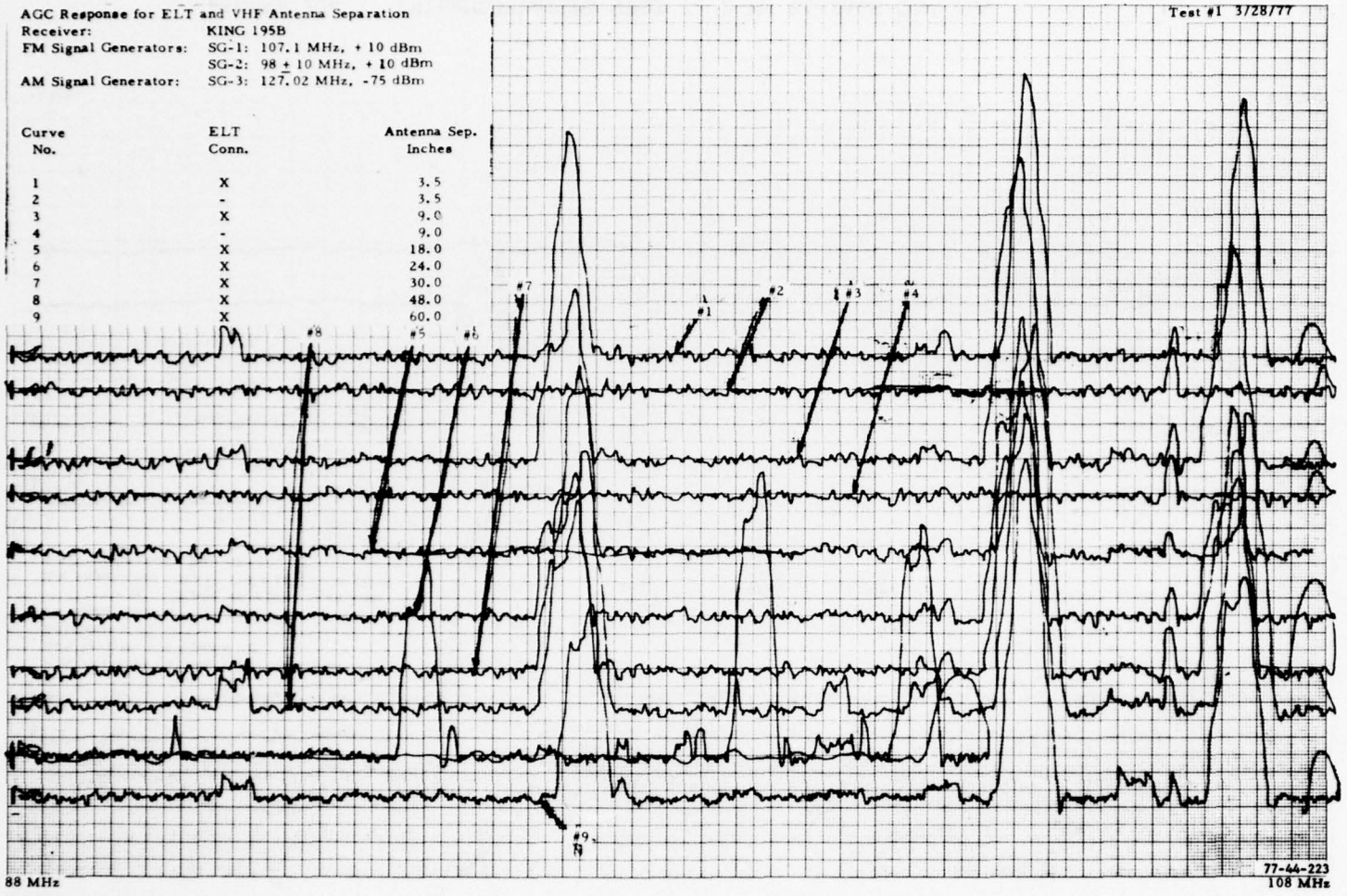


FIGURE 223. INTERMODULATION TEST, ELT/REC SEPARATION CHANGE, KING 195B

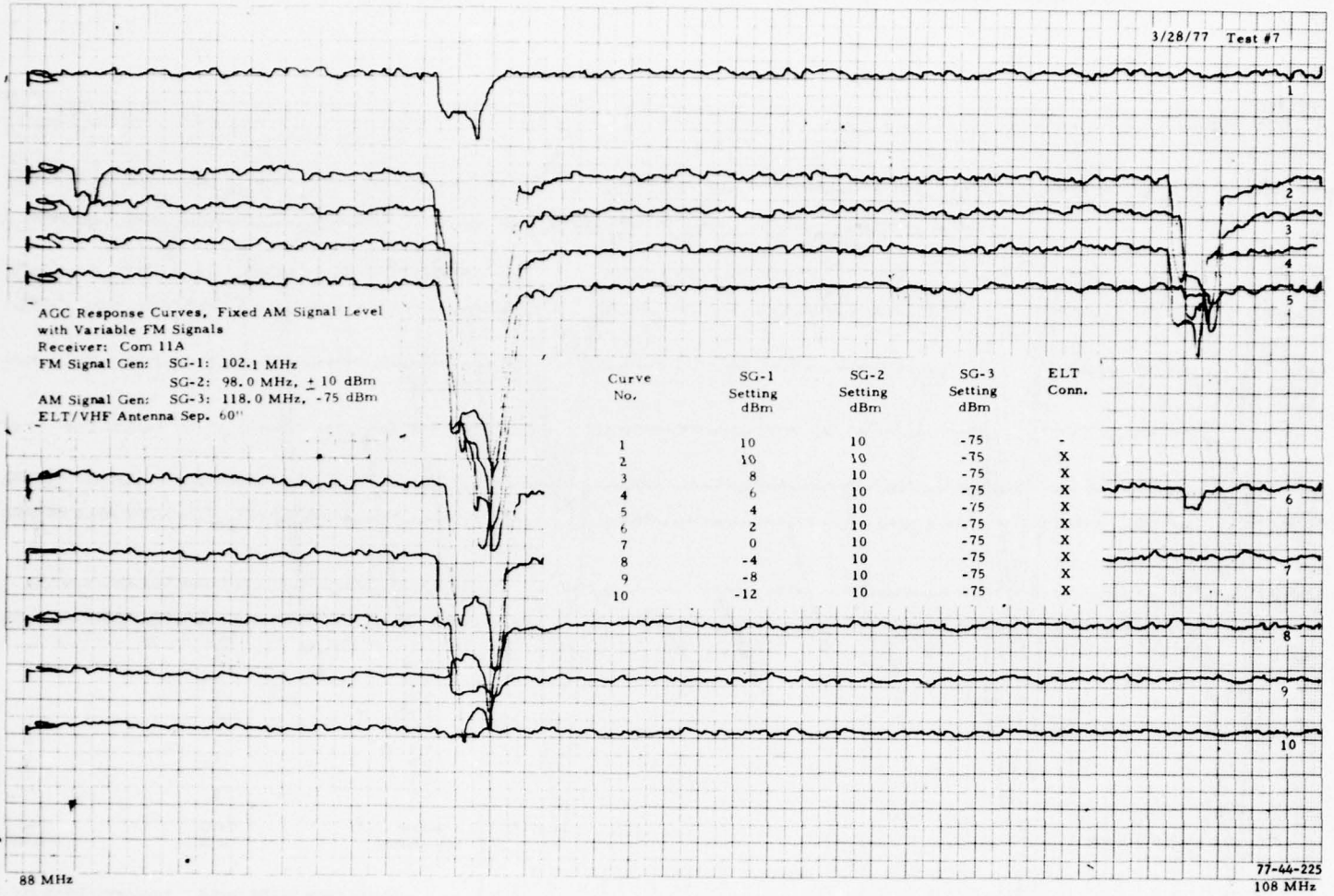


FIGURE 224. INTERMODULATION TEST 7, 2 FM SIGNALS COM 11A

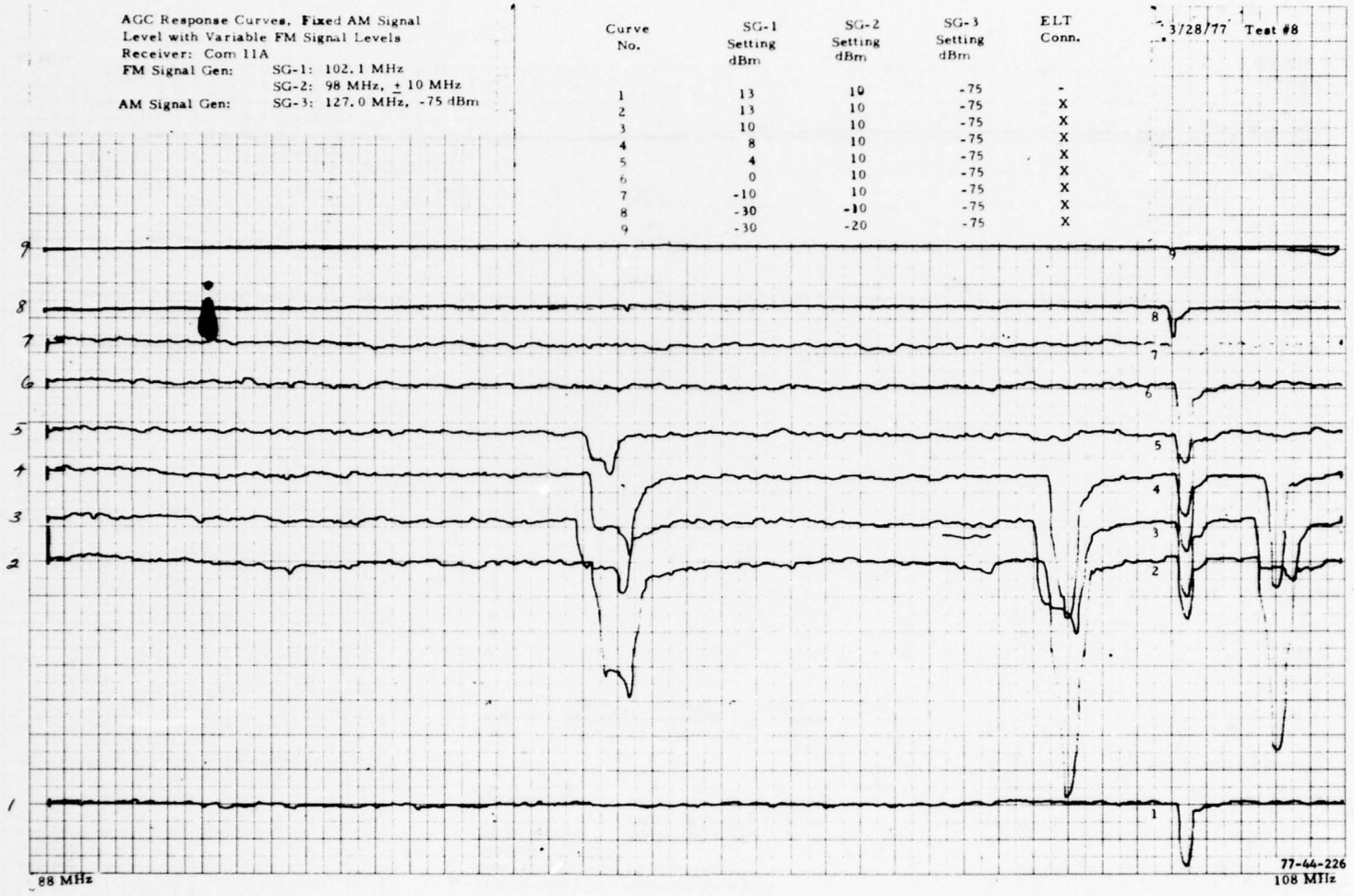


FIGURE 225. INTERMODULATION TEST 8, 2 FM SIGNALS COM 11 A

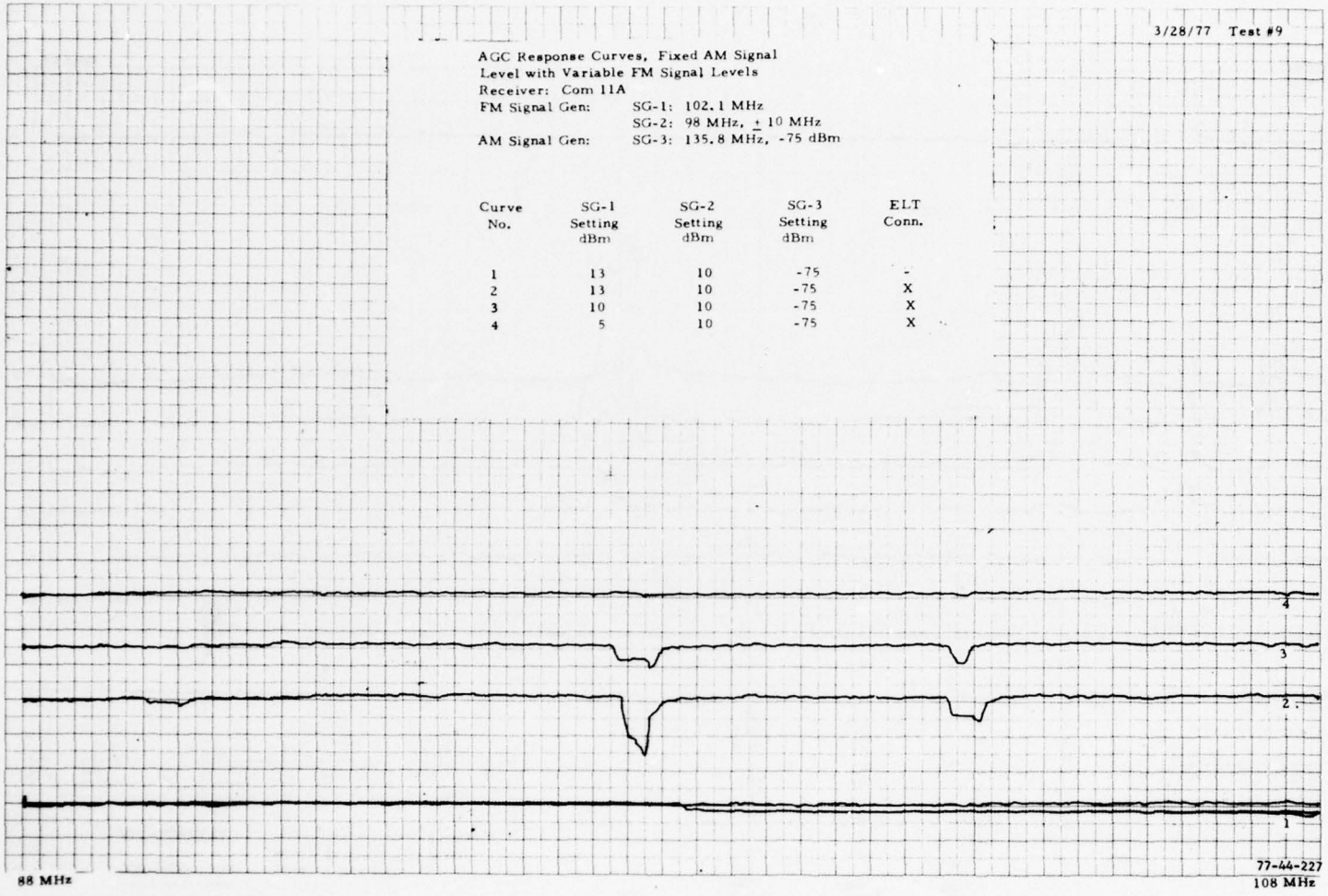


FIGURE 226. INTERMODULATION TEST 9, 2 FM SIGNALS COM 11A

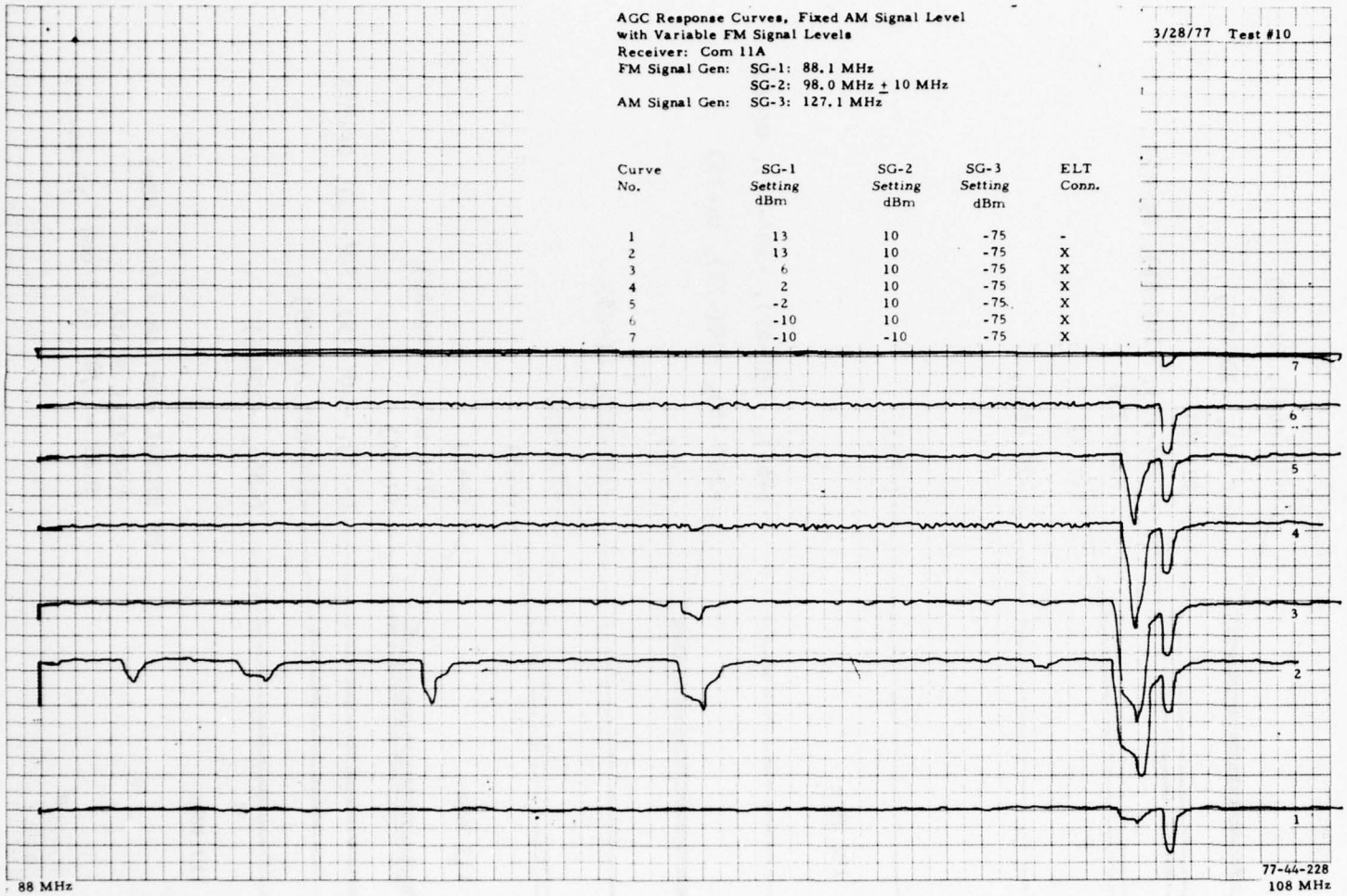


FIGURE 227. INTERMODULATION TEST 10, 2 FM SIGNALS COM 11A

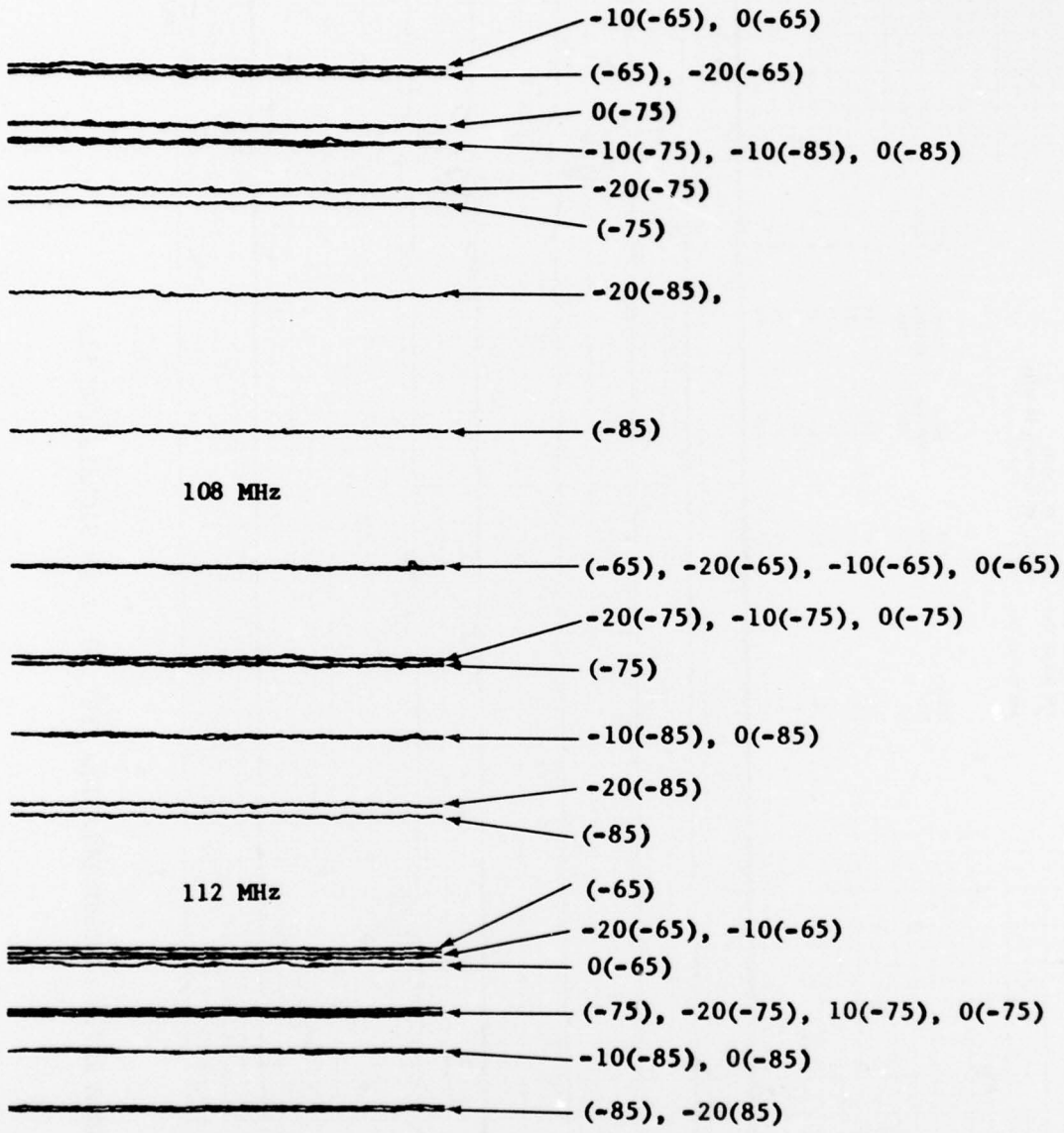
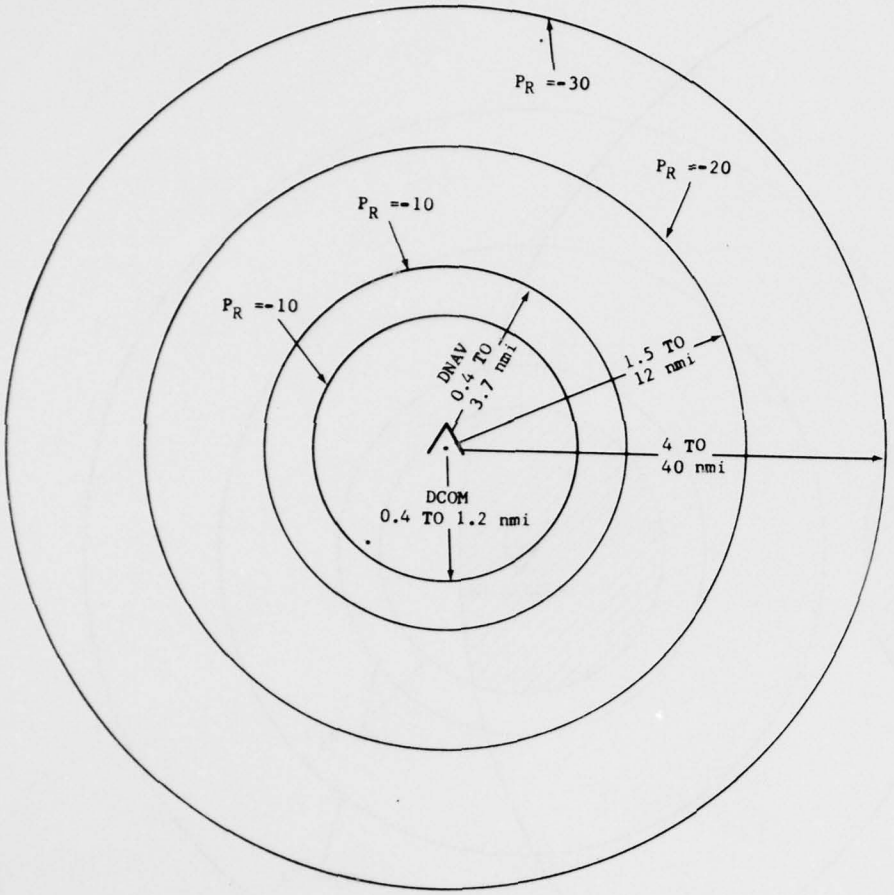


FIGURE 228. AGC RESPONSE, AM & FM SIGNALS BENDIX



KEY:

$P_{R\ DCOM}$ =-10 WITHIN THE SIGNAL LEVEL OF P_R =-10, DCOM INTERFERENCE TO COMM RECEIVERS WILL PROBABLY OCCUR WHEN ONE OR MORE OTHER STATIONS HAS A P_R =-30 CIRCLE WHICH OVERLAYS IT.

$P_{R\ DNAV}$ =-10 SAME CONDITION FOR NAV RECEIVERS AS FOR COM RECEIVERS BUT CIRCLE OF GREATER RADIOUS DUE TO AVIONIC ANTENNA FREQUENCY RESPONSE.

P_R =-20 BETWEEN P_R =-10 AND P_R =-20 INTERFERENCE MAY OCCUR IF THE CONDITION OF OTHER OVERLAYING STATIONS ARE MET.

P_R =-30 THE MINIMUM SIGNAL LEVEL WITHIN WHICH INTERMODULATION MAY BE EXPECTED.

77-44-230

FIGURE 229. RECEIVER SIGNAL LEVEL DIAGRAM FOR PRDCOM AND PRDNAV

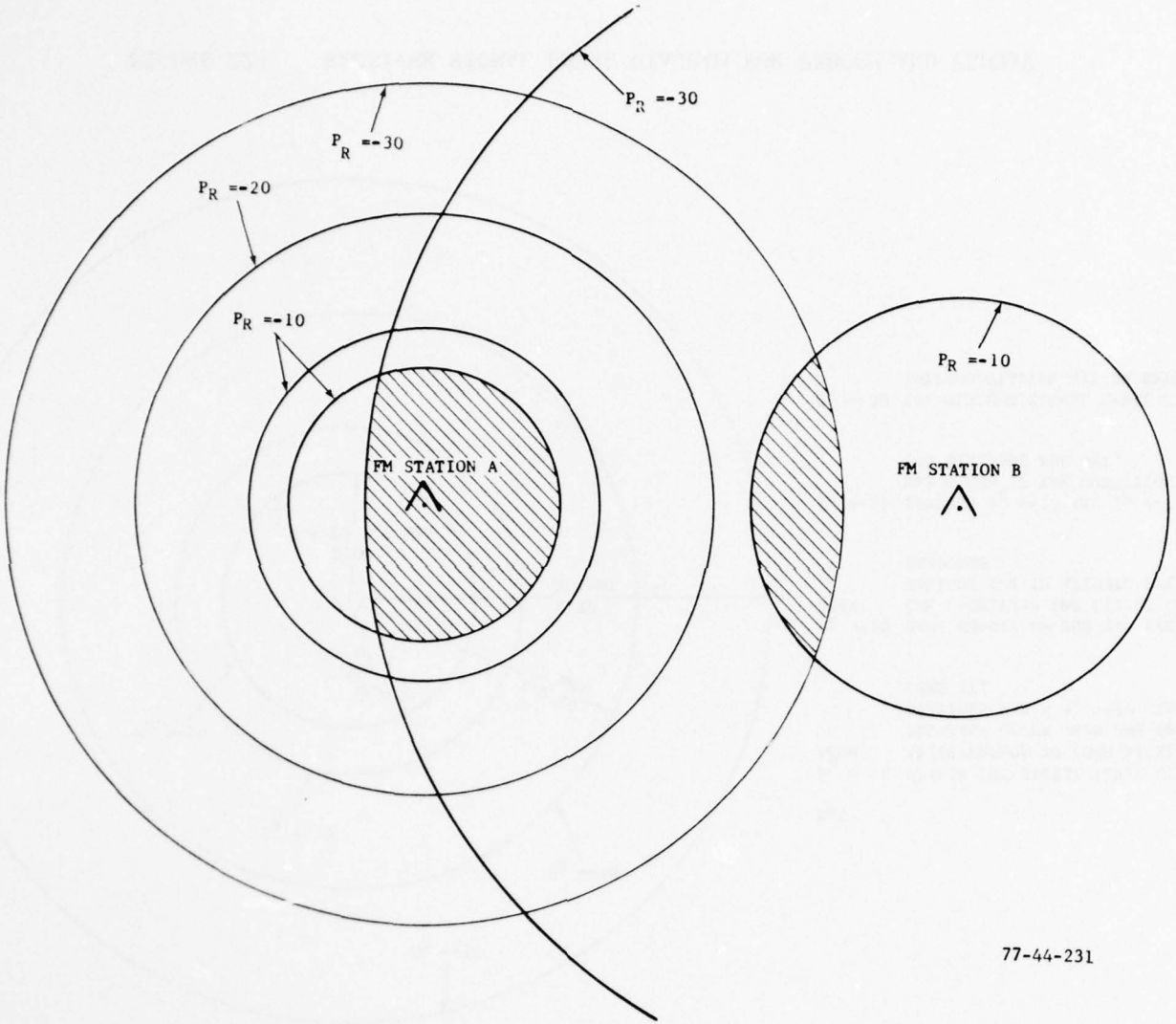


FIGURE 230. TWO FM STATION INTERFERENCE AREAS FOR PR = -10 AND PR = -30

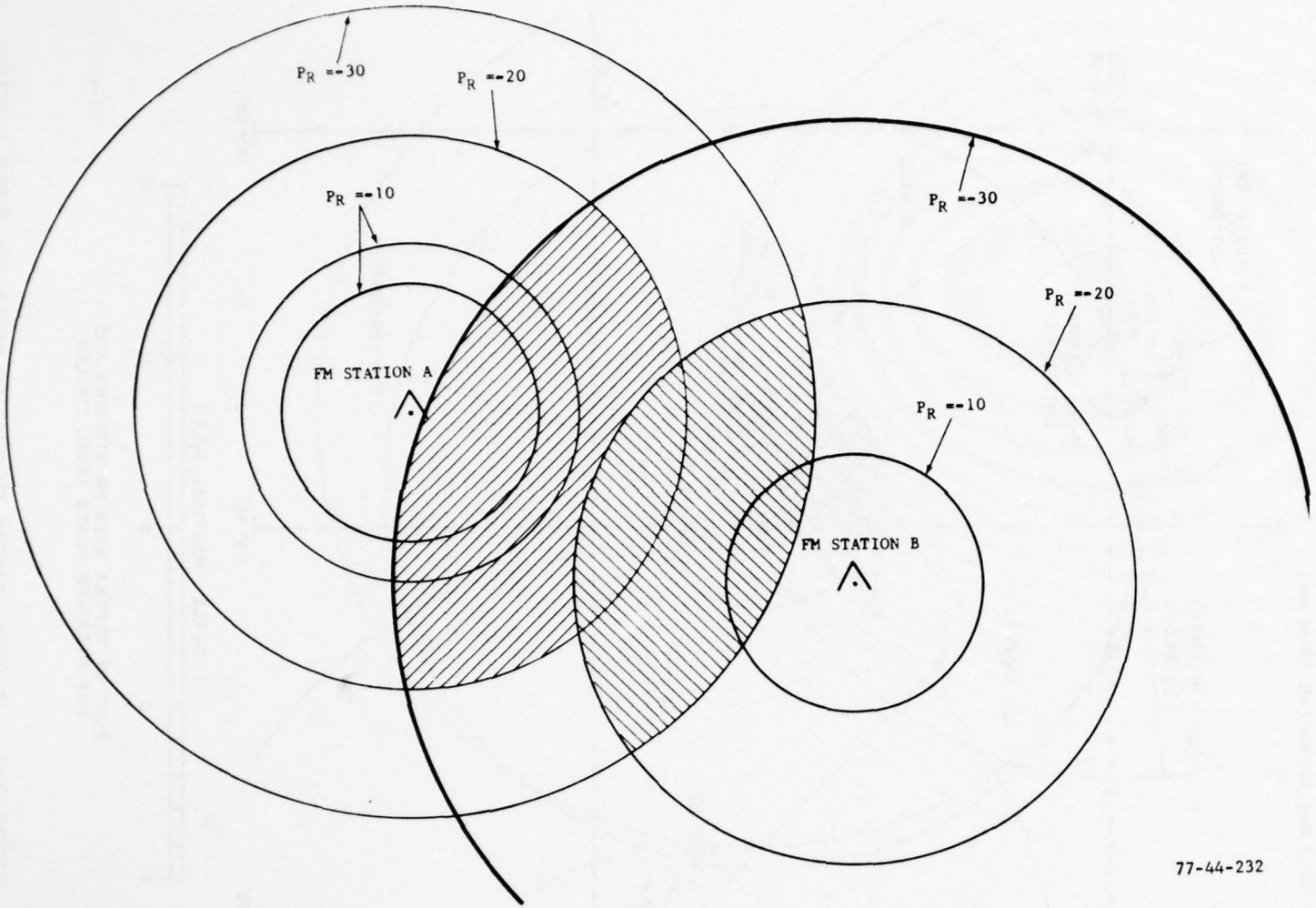


FIGURE 231. TWO FM STATION INTERFERENCE AREAS FOR PR = -20

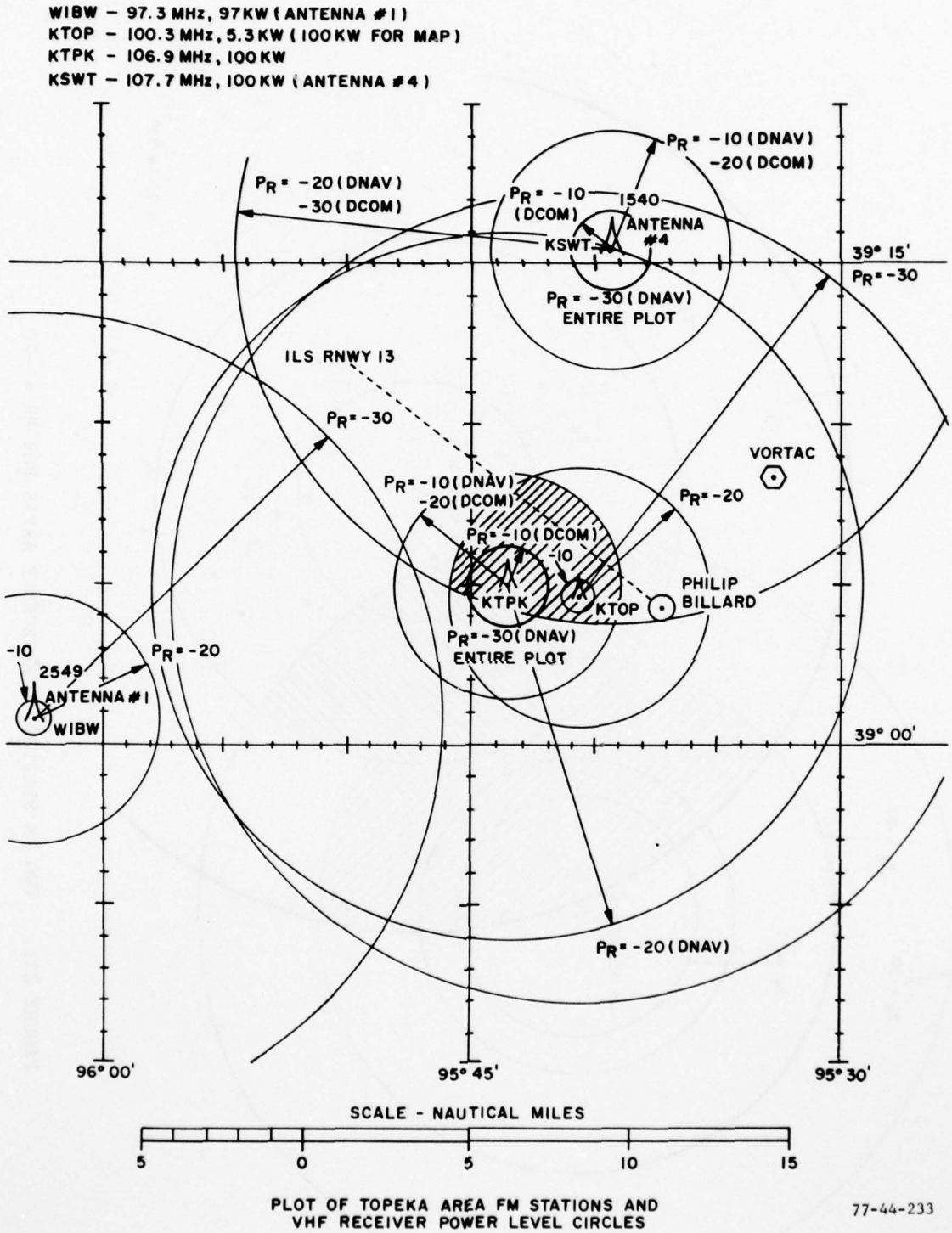


FIGURE 232. TOPEKA, KANSAS FM STATION RADIATION POWER CIRCLES

APPENDIX A

BRUTE FORCE INTERFERENCE CALCULATION

Step	Instructions	Input Data/Units	Keys		Output Data/Units
	This program calculates the distance required between an interfering station and an aeronautical receiver to prevent brute force desensitization, based on the space loss (Ls) between the two stations.				
1	Initialize		RTN	R/S	0.00
2	Calculate Ls in db (if known, skip to Step 3) Enter absolute values of the following:				
2A	Enter ERP in watts of interfering signal	ERP/Watts	ENTER		ERP/Watts
2B	Enter sensitivity in dBm of victim receiver	Sen/dBm	ENTER		Sen/dBm
2C	Enter losses in dB of victim antenna system	Loss/dB	ENTER		Loss/dB
2D	Enter out band bass rej. in dB of victim rec.	Rej/db	A		Ls/dB
3	Enter Ls in dB (skip if calculated above)	Ls/dB	B		Ls/dB
4	Enter frequency in MHz of interfering signal	Freq/MHz	C		Freq/MHz
5	Read distance in feet required between victim receiver and interfering transmitter		D		Dist/Ft.
6	Read distance in nautical miles required between victim receiver and interfering transmitter		E		Dist/nmi

Key Entry	Code Shown	Comments
F	31	
STK	42	Clear Stack.
Reg	43	Clear register
CLX	44	Clear X.
R/S	84	Display 0.00
LBL	23	Calculate Ls value
A	11	in db from absolute
+	61	values of effective
-	51	radiated power,
G⇄	3507	receiver sensitivity,
.	83	system loss, and
0	00	receiver rejection
0	00	
1	01	Ls=
+	81	
F	31	$\left(10 \text{ Log } \frac{ERP}{.001}\right)$(Rec Sen)-
Log	08	
1	01	(Sys Loss)-(Rec. Rej.)
0	00	
X	71	
+	61	
STO-1	3301	Store Ls value.
R/S	84	Display Ls value.
LBL	23	Enter Ls in dB when
B	12	known w/o calculation.
STO-1	3301	Store Ls value.
R/S	84	Display Ls value.
LBL	23	Enter freq. in MHz
C	13	of interfering signal.
STO-2	3302	Store freq. value.
R/S	84	Display freq. value.
LBL	23	Calculate distance
D	14	in feet.
RCL-1	3401	Ls in dB
3	03	
8	08	$Dist._{ft.} =$
-	51	
2	02	$6080 \left[\frac{Log^{-1}\left(\frac{Ls-38}{20}\right)}{Freq.\ MHz}\right]$
0	00	
+	81	
F^{-1}	32	
Log	08	
RCL-2	3402	Freq. in MHz.
+	80	
6	06	
0	00	
8	08	
0	00	
X	71	

Key Entry	Code Shown	Comments
STO-3	3303	Store dist. in ft.
P/S	84	Display dist. in ft.
LBL	23	Calculate distance
E	15	in nautical miles
RCL-1	3401	Ls in dB
3	03	
8	08	Dist. nmi +
-	51	
2	02	$\left[\frac{Log^{-1}\left(\frac{Ls-38}{20}\right)}{Freq.\ MHz}\right]$
0	00	
+	81	
F^{-1}	32	
log	08	
RCL-2	3402	Freq. in MHz.
+		
STO-4	3304	Store dist. in nmi
R/S	84	Display dist. in nmi

Registers

R_1 Ls in dB

R_2 Freq. in MHz

R_3 Dist. in ft.

R_4 Dist. in nmi

R_5

R_6

R_7

R_8

R_9

Labels

A Cal Ls
B Ent. Ls
C Ent Fr.
D Dist. Ft.
E Dist. nmi
0
1
2
3
4
5
6
7
8
9

Flags

1

2